EVALUATION OF GREAT LAKES MONITORING PROGRAMS TO ESTABLISH AN ADEQUATE STRATEGY

U. S. ENVIRONMENTAL PROTECTION AGENCY
SURVEILLANCE & ANALYSIS DIVISION
TECHNICAL SUPPORT BRANCH
TECHNICAL SERVICES SECTION
ONE NORTH WACKER DRIVE, CHICAGO, ILLINOIS

MARCH 16, 1973

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TABLE OF CONTENTS

PAGE(s)

I. INTRODUCTION ---------- 1

II. WHOLE GREAT LAKES BASELINE MEAN DATA ---------- 1

III. GREAT LAKES OPEN WATER DATA ---------- 2

IV. GREAT LAKES IN-SHORE DATA ---------- 2

V. NEEDED DATA TO ESTABLISH A DATA BASE ---------- 2

VI. EVALUATION OF CURRENT MONITORING PROGRAMS IN THE GREAT LAKES ---------- 2-3

A. Lakes Superior & Huron (Upper G. L.) ---------- 3
B. Lake Michigan ---------- 3
C. Lakes Erie & Ontario ---------- 3-4

VII. METHODOLOGY (SPECIAL) ---------- 4

A. Phenols ---------- 4
B. Phthalates ---------- 4
C. Polychlorinated Biphenyls (PCBs) ---------- 4

VIII. RECOMMENDATIONS ---------- 4

IX. CONCLUSIONS ---------- 5

APPENDIX ---------- 1-A-0,1V

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUBJECT: Evaluating Great Lakes Monitoring Parameters to aid in Developing an adequate base-line, establish cause and effect, and needed surveys for the Great Lakes

DATE: March 15, 1973

FROM: W. D. Johnson
THRU: E. Pinkstaff

TO: M. W. Tellekson
Chief, Technical Support Branch

I. INTRODUCTION

A. The "Outline of Monitoring Strategy on Lakes Michigan, Erie, Ontario" dated 2-14-73 from W. D. Johnson to Merle Tellekson, enumerates most of the agencies involved in studies on the lower Great Lakes. (1)

B. The "Draft Preliminary Outline of Monitoring Strategy for Pesticides in the Great Lakes", dated 2-23-73, from W. D. Johnson to Merle Tellekson, presents a tentative plan for the Surveillance of Pesticides in the Great Lakes. (2)

C. This evaluation will explore: . The "Storet System" to obtain data and information about the deep water and in-shore waters to establish whether there is enough information to establish a data base for the Great Lakes, and to point out Storet gaps in the base-line picture of the Great Lakes. (See Appendix 1.)

The Storet data will include 5 year averages starting from 1960 to present for some of the most used pesticides (from a 1966 use survey) and 45 parameters as shown in Appendix 1.

II. WHOLE GREAT LAKES BASE-LINE MEAN DATA

Base-line and other data from Storet, the Great Lakes States, IJC, IFYGL, other Federal and private agencies will be referenced (see table 1A and 1B).

The following appendices give general base-line characteristics of the Great Lakes:

Appendix A - Lakes Superior, Huron, Michigan and Erie (15)
Appendices B - 1&2 - Lakes Erie and Ontario (16)
Appendices C - 2&3 - Lakes Erie, Southern L. Mich. & Superior

III. GREAT LAKES OPEN WATER DATA

(See Storet Data Appendix D)
(See also, Appendix H)

IV. GREAT LAKES IN-SHORE DATA

(See Storet and/or other data in Appendix E)

V. NEEDED DATA TO ESTABLISH DATA BASE

1. All data sources appear to be deficient in organic baseline data, such as:

a. Pesticides, PCBS, Phthalates, carbon chloroform extractables, carbon alcohol extractables and phenols, in both in-shore and open waters.

2. Reference (19) indicates some of the needed parameter monitoring programs for Lake Michigan for in-shore and open waters: relevant industrial waste parameters, chlorides, pesticides, phthalates, and trace metals. (Appendix F)

3. Reference (20) in Appendix G lists 12"Special Attention" areas which must be monitored for appropriate parameter such as given in Table 1A and 1B.

4. Data from industrial monitoring program associated with power plant discharges is needed to assess ecological effects for necessary remedial action. (See Appendix I).

5. Appendix J indicates that a minimum of 2 lakewide cruises per year are neede to assess total and soluble phosphorous, nitrate- nitrogen, and reactive silica. A secondary concurrent program would be to collect data also, on ammonia and nitrate-nitrogen, conservative ions (chlorides, sulfates, calcium, magnesium, sodium, potassium) alkalinity, conductivity, and pH. Parameters like DO should be measured IN SITU aboard ship.

6. Appendix K indicates the need for atmospheric monitoring with U. Michigan's capability to assist Region V, S&A Division in setting up a network, if necessary.

VI. EVALUATION OF CURRENT MONITORING PROGRAMS IN THE GREAT LAKES LAKE SUPERIOR & HURON (UPPER GREAT LAKES)

A. IJC's Upper Great Lakes Water Quality Studies - Preliminary Plan by IJC Upper Great Lakes Reference Group, dated Feb. 1973, appears to be adequate to assess:

LAKE SUPERIOR'S AND LAKE HURON'S WATER QUALITY

(See Appendix L) along with contributors in Table 1A & B.

B. LAKE MICHIGAN (One of Lower G. L.)

The following contributors are monitoring Lake Michigan:

1. Interstate Electronic Corporation is making a study titled "Chicago Study Monitoring Activities" as shown in Appendix M extending in-shore from Wisconsin-Illinois line to New Buffalo, Michigan, showing 15 contributors.

2. U. Wisconsin - Milwaukee is studying TFM (3 -Trifluromethyl - Nitrophenol) in Milwaukee Harbor, Biota after chlorination effluents (same location) Thermal Pollution, at Oak Creek, Wisc. (See Appendix N)

3. U. S. Forest Service (Appendix O) is doing total and fecal coliform for recreation safety near Brevoort Lake and also at Porter Creek.

4. Gross IL Laboratory (Appendix R) anticipating work to assess an algae CLADOPHORA with nutrient info and hazardous materials.

5. US EPA District Offices are doing limited monitoring along with States adjacent to Lake Michigan (Appendix V, Ref. 1&2)

The above and table 1A & B Programs are inadequate to assess the in-shore and open waters of Lake Michigan.

A Program similar to the IJC for Upper Great Lakes with more emphasis on industrial and municipal waste parameter monitors on in-shore waters as given in Appendix G is needed for Lake Michigan.

C. LAKES ERIE AND ONTARIO

a. The "Lake Erie Nutrient Control Program: An assessment of its effectiveness in controlling lake eutrophication" to run from 4-1-73 to 3-31-74 for parameter on Page 10 under procedure (See Appendix Q).

b. Programs in Tables 1A & B and references 1, 2, & 4 and Appendix G indicates that adequate monitoring programs are progressing for Lakes Erie and Ontario.

However, adequate programs for in-shore critical point and non-point sources should be developed in the future for the Great Lakes, especially for organic parameters like pesticides, PCB's and phthalates. This monitoring is needed for 1973 and continuing thru 1974 or until enough data is accumulated to assess the pollutional effects on the Great Lakes.

VII. METHODOLOGY

In general the methods references (1) and (2) should be employed, employing analytical quality control practices for all parameters. Special referenced ... methods are:

A. Phenols ----------Appendix S
B. Phthalates----------Appendix T
C. Polychlorinated Biphenyls----Appendix U

VIII. RECOMMENDATIONS

A. A more detailed study of industrial, municipal, and agricultural wastes should be made for the Great Lakes including tributaries discharging into the lakes. This may be shown graphically so that a better and more effective in-shore monitoring program may be established.

B. Lake Michigan should be given special attention with respect to nutrient or eutrophication parameters like phosphorus and nitrogens, common ions like chlorides, sulfates, and organic pollutants like PCB's, phthalates, phenols, and pesticides, also toxic metals like mercury, lead, nickel, copper, zinc, cadmium. Lake Michigan's trend towards eutrophication (aging) may be reversed or halted, if control limits are put on these substances concentrations, with necessary enforcements.

C. Request that all Great Lakes data contributors report results to Storet or to the Regional Surveillance & Analysis Division Director.

D. Recommend that the monitoring strategy given in Reference (1) and (2) be effected with modifications given in this evaluation.

IX CONCLUSIONS

A. The monitoring strategy recommended will permit better coordination of Great Lakes data contributors.

B. This monitoring strategy will permit a more thorough economical coverage of the Great Lakes.

C. Immediate action in effecting this monitoring strategy is advised, since delays are costly as evidenced by the effort needed to clean up Lake Erie.

W. D. Johnson

W. D. Johnson

REFERENCES:

1. Johnson, W. Dewitt, U.S. EPA - Region V - S & A Div., "Outline of Monitoring Strategy on Lakes Michigan, Erie, and Ontario" memo dated 2-14-73 to Merle W. Tellekson, Chief, Technical Support Branch, Region V - USEPA Chicago, Illinois.

2. Ibid, "Draft Preliminary Outline of Monitoring Strategy for Pesticides in the Great Lakes" memo dated 2-3-73 to Merle W. Tellekson, Chief, Technical Support Branch, Region V - USEPA, Chicago, Illinois.

3. U S D I - FWPCA - GLR - LHBO - "Lake Huron - Michigan Water Quality Data 1965 Survey", Clean Water Series LHBO - 17-A, January 1969, Gross Ile, Michigan 48138.

4. U.S. EPA - Region V Storet (Direct Communication)

5. IL - EPA "Lake Michigan Open Water and Lake Bed Survey 1970", Richard B. Ogilvie, Gov., & William L. Blaser, Director.

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7. USEPA - OR & M - An eualuation of DDT & Dieldrin in Lake Michigan, Ecological Research Service & EPA - R . 3 - 72-003 August 1972 Washington, DC. 20460

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10. Johnson, W. D.; Pesticides in Green Bay area Proc. 10th Conf. GL. Res. 1967 (USDI - FWPCA, Chicago, Illinois).

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18. University of Illinois - Water Resources Center, (Dr. Ben B. Ewing, Director et al) Feasibility of Evaluating of Benefits from Improved Great Lakes Water Quality, WRC Special Report No. 2, prepared for U.S. Corp. of Engrs. under contract No. DACW 23-68-0037. WRC - U of Il - 3220 Civil Engr. Bldg., Urbana, Il. 61801, May 1968.

19. Letter USEPA - RV dated 3-7-73 from Walter W. Kovalick Jr. Adm. Asst. ORA S & A Division, Director, Subject L M E C Non- thermal Issues - Follow-up.

20. Ibid, dated 3-5-73 From James O. McDonald, Dir. Enf. Div. to Dr. Robert W. Zeller, Dir. S & A Division, Subject; Great Lakes Initiative Contract Program.

21. Ibid, dated 2-26-73, from Walter W. Kovalick Jr. Adm. Asst. ORA, to Dir. S & A Division Subject; Critique on Enviro-Control Briefing, Feb. 16,1973.

22. US - Canada, International Field Year for the Great Lakes (IFYGL) (Lake Ontario Study) IFYGL Bulletin No. 4 Sept. 1972, Pub: NOAA, USDC, Rockville, Md. 20852.

TABLE 1A SOME AGENCIES OF GREAT LAKES SELECTED PARAMETERS FOR BASELINE DATA INDICATIONS

PARAMETER \ AGENCY	STORET-USEPA	U. of MICH. & STATE OF MICHIGAN	*WISCONSIN	*ILLINOIS & U OF ILLINOIS	*INDIANA	*OHIO	*PENNSYLVANIA	*NEW YORK	I J C	I F Y G L	USDI FWPCA	W.D. JOHNSON ET AL	LAKE MICHIGAN ENF. CONF. US EPA	US-EPA OR&M	USDHEW PHS DWSR	OPR: HYPO US & CANADA
Temp °C	(4) GL	(3) LM (15) GL LO		(5) LM (18) LSME					(1) LO (18) LEC	(21) LO	(6) GB				(12) LM	(13) LE
Conductivity																
Turbidity									(16) LO							
Phenols		(3)									(6)					
Ammonia-N		(3) (15)							(16)	(21)	(6)				(12)	(13)
pH		(3)													(12)	(13)
Total Nonfil Residue(Solids)		(3) (15)									(6)				(12)	
Dissolved Residue(solids)									(16)		(6)					
Total Residue		(3)														
D O		(15)		(18)							(6)				(12)	(13)
BOD																
Total Nitrates		(15)							(16)	(21)						(13)
Total Organic Nitrogen									(16)		(6)					

TABLE 1A SOME AGENCIES OF GREAT LAKES SELECTED PARAMETERS FOR BASELINE DATA INDICATIONS

PARAMETER \ AGENCY	STORET-USEPA	*U. of MICH. & STATE OF MICHIGAN	*WISCONSIN	*ILLINOIS & U OF ILLINOIS	*INDIANA	*OHIO	*PENNSYLVANIA	*NEW YORK	I J C	I F Y G L	USDI FWPCA	W.D. JOHNSON ET AL	LAKE MICHIGAN ENF. CONF. US EPA	US-EPA OR&M	USDHEW PHS DWSR	OPR: HYPO US & CANADA
Total Otho		(3)(15)		(18) (5)						(21)	(6)					
Tot. Org. Phosphates																
Tot.Phosphates		(3)							(16)	(21)	(6)				(12)	
Silica-Dissol.		(15)		(18)						(21)	(6)					
Alkalinity Phenols									(16)						(12)	
Alkalinity Total		(15)		(18)						(21)					(12)	
Calcium		(15)		(18)					(16)		(6)(17)		(7) LM			
Magnesium											(6)					
Potassium									(16)		(17)					
Chlorides		(15)									(6)(17)		(11)			
Sulfates		(15)									(6)(17)					
Cadmium										(21)	(6)					
Total Iron				(18)												

GL = Great Lakes
LM = Lake Michigan
LSME = Lakes Superior, Michigan, & Erie
LO = Lake Ontario
E = Lake Erie

TABLE 1B SOME AGENCIES OF GREAT LAKES SELECTED PARAMETERS FOR BASELINE DATA INDICATIONS

PARAMETER \ AGENCY	STORET-USEPA	U. of MICH. & STATE OF MICHIGAN	WISCONSIN	ILLINOIS & U OF ILLINOIS	INDIANA	OHIO	PENNSYLVANIA	NEW YORK	I J C	I F Y G L	USDI FWPCA	W.D. JOHNSON ET AL	LAKE MICHIGAN ENF. CONF. US EPA	US-EPA OR&M	USDHEW PHS DWSR	OPR: HYPO US & CANADA
Chromium	(4) GL			(5) LM					(1)(14) UL	(10) LO	(6) GB			(7) LM		
Copper															(12) LM	
Lead																
Nickel																
Zinc																
Arsenic																
Dieldrin												(10) GB				
Tot. DDT												(10)				
Toxaphene																
Aldrin												(10)				
Diazinon																
Sevin																
2,4,5-T13																
2,4-D																
Parathion																
PCBs																

TABLE 1B SOME AGENCIES OF GREAT LAKES SELECTED PARAMETERS FOR BASELINE DATA INDICATIONS

PARAMETER \ AGENCY	STORET-USEPA	*U. of MICH. & STATE OF MICHIGAN	*WISCONSIN	*ILLINOIS & U OF ILLINOIS	*INDIANA	*OHIO	*PENNSYLVANIA	*NEW YORK	I J C	I F Y G L	USDI FWPCA	W.D. JOHNSON ET AL	LAKE MICHIGAN ENF. CONF. US EPA	US-EPA OR&M	USDHEW PHS DWSR	OPR: HTPO US & CANADA
Phthalates	(4)			(5)					(1)(24)UL							
Detergents				(18)							(6)				(12) LM	
Alpha Radiation				(18)												
Beta "				(18)												
Gamma "																
Microbiology										(21)	(6)					
Macrobiology		(15) GL-LO									(6)					(13) LE
Mercury														(7)		(13)
Bottom Sed.T.		(15)									(6)					
Alk.Earths											(6)				(12)	(13)
Organics				(18)						(21)						(13)

GL = Great Lakes
UL = Lakes Superior & Huron
LM = Lake Michigan

LE = L. Erie
LO = L. Ontario

*Physical & Selected Parameters Sent to USEPA Storet

APPENDIX E

(GREAT LAKES INSHORE DATA AVAILABLE FROM US EPA-RII STORET, see also, Reference 1 & 2)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY APPENDIX 1.

SUBJECT: Evaluating Great Lakes Water Quality Parameters in Designated Deep Water Polygon Lat-Lon

DATE: March 15, 1973

FROM: W. D. Johnson

TO: Robert Bowden

1. Give Storet Data (Statistical Means with STD DEAV, Max - Min, Variance & Confidence Limits for the Parameters (1960 to present), with 5 year averages and overall averages:

CODE	PARAMETER
39380	Dieldrin
39370	Total DDT
39516	PCBs
39400	Toxaphene
39330	Aldrin
39750	Sevin
39750	Diazinon
39740	2,4,5 - T
39730	2,4 - D
39540	Parathion

EVALUATION OF WATER QUALITY IN GREAT LAKES

APPENDIX 1

LAKE SUPERIOR POLYGON:

POINT		LONGITUDE	LATITUDE
A	=	91° 18' 00"	47° 23' 00"
B	=	87° 10' 00"	48° 35' 00"
C	=	84° 52' 00"	46° 47' 00"
D	=	87° 17' 00"	46° 33' 00"
E	=	87° 48' 00"	47° 35' 00"
F	=	90° 26' 00"	46° 36' 00"

LAKE HURON

G	=	83° 45' 00"	45° 47' 00"
H	=	81° 48' 00"	45° 22' 00"
I	=	82° 02' 00"	43° 17' 00"
J	=	81° 38' 00"	45° 28' 00"
K	=	81° 04' 00"	45° 53' 00"
L	=	80° 08' 00"	44° 32' 00"

LAKE MICHIGAN

M	=	87° 28' 00"	41° 54' 00"
N	=	87° 41' 00"	43° 00' 00"
O	=	87° 32' 00"	44° 00' 00"
P	=	86° 11' 00"	45° 53' 00"
Q	=	85° 42' 00"	45° 53' 00"
R	=	86° 43' 00"	44° 00' 00"
S	=	86° 20' 00"	43° 00' 00"
T	=	86° 37' 00"	41° 54' 00"

Summary L. Michigan 3
Polygon given above:

Upper MNST
Middle NORS
Lower Basin OPQR

EVALUATION OF WATER QUALITY IN GREAT LAKES (continued)

APPENDIX I

LAKE ERIE

	POINT		LONGITUDE	LATITUDE
Western Basin	U	=	82° 23' 00"	42° 03' 00"
	V	=	82° 23' 00"	42° 32' 00"
Eastern Basin	W	=	80° 30' 00"	42° 30' 00"
	X	=	80° 30' 00"	42° 00' 00"
	Y	=	79° 18' 00"	42° 35' 00"

LAKE ONTARIO

Z	=	79° 00' 00"	43° 47' 00"
A-1		76° 27' 00"	43° 50' 00"
B-1		76° 30' 00"	43° 30' 00"
C-1		79° 37' 00"	43° 18' 00"

Coordinates were rechecked by W. D. Johnson & Robert Bowden

Ref 7; Evol 15 (To: WD) | Jim U. Mich.-Dr Schelske & (Res Limnologist) Dr Eugene F Stoermer (Research Algologist)

APPENDIX A From: Paper PREPublication 17

Rec'd 2-16-73

TABLE ~~37~~ 35. Benthos data summary. For each taxon and lake zone, the mean percentage of the total fauna is given. The mean numerical total (number/m^2) is given for each lake zone, as well as the ratio of total Crustacea to total Oligochaeta.

Taxa	Lake Zones									
	Superior Open Lake	Superior Bays	Huron Zone I	Michigan	Huron Zone II	Huron Zone IV	Saginaw Bay	Erie Zone I	Erie Zone II	Erie Zone III
Pontoporeia	54.9	50.8	71.6	66.6	52.0	31.5	0.9			
Mysis	1.8	0.9	0.3		0.3					
Chironomidae	5.2	7.7	2.6	1.7	2.3	8.3	10.4	5.8	11.1	18.2
Gastropoda	0.1		0.3	0.9	0.2	0.8	0.1	7.1	0.7	0.1
Sphaeriidae	8.0	13.7	3.1	7.2	5.0	1.2	0.5	22.6	5.1	23.9
Gammarus					0.4		3.1	3.0	0.7	0.1
Hirudinea					0.1		0.1	0.3	0.9	0.2
Oligochaeta	20.9	26.8	22.0	23.2	39.7	52.7	83.7	57.4	81.4	57.5
Other	0.1		0.1	0.4	0.6	5.4	1.1	1.6	0.2	
Total No./m^2	376	482	1863	3222	4837	623	3499	2967	4204	2293
Σcrustacea/ Σoligochaeta	2.71	1.92	3.27	2.87	1.33	0.60	0.05	0.05	0.01	0.001

TABLE ~~30.~~ 24. Zooplankton data summary. For each genus and lake zone, the abundance is represented by the mean value of the relative abundance index (example: 5.0 = dominant at every station). Where no value appears, the genus was not found at any station in that zone. The average number of genera per station, the average settled volume and the ratio of total calanoids to total cladocerans and rotifers is also given for each lake zone.

Genera	Lake Zones									
	Superior Open Lake	Superior Bays	Huron Zone II	Michigan	Huron Zone I	Huron Zone IV	Erie Zone III	Saginaw Bay	Erie Zone I	Erie Zone II
Calanoid copepods										
Limnocalanus	3.2	3.0	1.5		1.7		0.1			
Diaptomus	5.0	5.0	5.0	4.4	4.7	4.6	4.2	2.8	2.6	2.1
Senecella	0.5		0.2		0.3					
Epischura			0.1							
Mysis	0.1									
Cyclopoid copepods										
Cyclops	2.1	3.6	3.9	4.2	3.8	4.0	4.0	2.8	3.6	3.1
Mesocyclops										
Cladocerans										
Polyphemus	*	0.4	0.5		0.3	0.8				
Bosmina	0.1	1.8	3.9	5.0	4.3	3.6	2.1	4.3	4.0	3.6
Holopedium		0.8	2.5		2.6	3.0		0.5	0.8	0.4
Leptodora	*	0.4	0.1		0.1	1.4	1.2	2.5	2.6	2.5
Daphnia	0.2	1.6	1.7	1.5	2.4	2.2	4.7	2.8	3.6	4.2
Ceriodaphnia								0.5		
Diaphanosoma							1.4		2.0	1.4
Rotifers										
Kellicottia				0.2						
Asplanchna	0.3	1.8	1.6	0.2	1.4	1.4	2.4	3.5	1.4	
Unident. Rotifer							0.5	2.5	1.0	
Average no. of genera/station	3.8	7.0	7.2	4.2	6.9	7.4	6.4	6.7	7.4	6.4
Settled volume, ml/m^3	0.35	0.38	1.11	1.92	0.92	0.77	8.32	0.67	3.93	8.75
Σcalanoids/ Σcladocerans & rotifers	14.50	1.18	0.67	0.64	0.60	0.37	0.35	0.17	0.17	0.17

*less than 0.[illegible]

TABLE 32. Relative abundance of phytoplankton as per cent occurrence in collections from Lake Superior, Lake Michigan, Lake Huron and Lake Erie.

Genus	L. Superior	L. Michigan	L. Huron	L. Erie	Average %
Fragilaria	73	100	100	90	90.8
Tabellaria	100	100	96	40	84.0
Asterionella	100	80	92	50	80.5
Synedra	100	100	76	30	76.5
Dinobryon	91	100	80	10	70.3
Melosira	82	80	84	20	66.5
Anabaena	24	60	76	75	58.8
Rhizoselenia	61	100	36	0	49.3
Pediastrum	6	20	48	90	41.0
Cyclotella	56	20	72	5	38.3
Oscillatoria	9	60	52	5	34.7
Ceratium	0	0	60	70	32.5
Microcystis	0	0	40	80	30.0
Aphanizomenon	0	0	24	85	27.3
Lyngbya	67	20	4	15	26.5
Gloecystis	12	0	40	35	21.8
Staurastrum	0	0	32	55	21.8
Cymbella	40	20	20	0	20.0
Stephanodiscus	30	20	24	5	19.8
Navicula	30	20	20	0	17.5
Oedogonium	0	0	12	45	14.3

TABLE 33. Relative abundance of phytoplankton as per cent occurrence in collection from Lake Superior, Lake Michigan, Lake Huron and Lake Erie.

Genus	L. Superior	L. Michigan	L. Huron	L. Erie	Average %
Gomphosphaeria	3	20	12	10	11.3
Merismopedia	12	0	0	0	3.0
Chroococcus	12	20	0	0	8.0
Peridinium	3	0	8	5	4.0
Amphiprora	3	0	4	0	1.8
Dactyloccopsis	3	0	0	0	0.8
Planktonema	3	20	4	0	6.8
Spirogyra	3	0	0	0	0.8
Mougeotia	3	0	0	0	0.8
Stauroneis	3	0	4	0	1.8
Nephrocytium	3	0	0	0	0.8
Oocystis	3	20	0	10	8.3
Gyrosigma	0	20	0	0	5.0
Uroglenopsis	0	20	0	0	5.0
Botryococcus	0	20	12	0	8.0
Dictyosphaerium	0	20	4	0	6.0
Mallomonas	0	20	0	0	5.0
Amphipleura	0	0	12	0	3.0
Coscinodiscus	0	0	12	10	5.5
Cosmarium	0	0	8	25	8.3
Phromidium	0	0	8	0	2.0
Synura	0	0	8	0	2.0
Amphiprora	0	0	4	0	1.0
Chodatella	0	0	4	0	1.0
Closterium	0	0	4	10	3.5
Coelastrum	0	0	4	0	1.0
Cosmocladium	0	0	4	0	1.0
Eudorina	0	0	4	0	1.0

Continued---

TABLE 33 continued

Genus	L. Superior	L. Michigan	L. Huron	L. Erie	Average %
Scenedesmus	0	0	4	5	2.3
Sphaerocystis	0	0	4	10	3.5
Sphaerozosma	0	0	4	0	1.0
Ulothrix	0	0	4	5	2.3
Actinastrum	0	0	0	5	1.3
Coelosphaerium	0	0	0	5	1.3
Colacium	0	0	0	5	1.3
Crucigenia	0	0	0	5	1.3
Tribonema	0	0	0	5	1.3

30

TABLE 31. Phytoplankton identified by genera at stations in the four lakes.

	Superior	Michigan	Huron	Erie
Stations sampled	33	5	25	20
Total number of genera	28	24	43	34
Average number of genera/station	9.7	10.8	12.3	9.4

TABLE 29. Summary of transparency, chlorophyll *a*, carbon fixation and assimilation ratio in all zones of the four lakes. Data for each parameter are given as the mean ± one standard deviation followed by the number of observations.

	Secchi disc	Chlorophyll	Carbon fixation	Assimilation ratio
Lake Superior				
Open lake	12.6 ± 3.4 (30)	0.66 ± 0.42 (27)	0.37 ± 0.18 (67)	0.82 ± 0.45 (15)
Bays	6.6 ± 1.1 (5)	1.46 ± 0.19 (5)	0.59 ± 0.14 (15)	
Lake Huron				
Open lake (I)	9.1 ± 2.4 (7)	0.81 ± 0.72 (7)	0.77 ± 0.38 (4)	1.26 ± 1.0 (4)
" " (II)	8.0 ± 2.4 (7)	0.86 ± 0.46 (8)	1.69 ± 0.51 (5)	2.67 ± 1.4 (5)
" " (III)	5.9 ± 0.62 (5)	0.86 ± 0.04 (4)	1.50 ± 0.53 (4)	1.76 ± 0.63 (4)
Bays (IV)	1.8 ± 0.40 (6)	7.26 ± 3.1 (6)	28 ±17 (5)	4.16 ± 2.5 (5)
Lake Michigan				
Open lake	4.8 ± 0.6 (6)	1.34 ± 0.62 (7)	2.40 ± 0.82 (13)	0.74
Lake Erie				
W.B.North	1.96 ± 0.43 (5)	3.65 ± 1.3 (5)	11 ± 5.1 (3)	3.75 ± 2.9 (3)
W.B.South	1.99 ± 0.53 (7)	12.1 ± 3.8 (7)	58 ±18 (5)	4.91 ± 0.78 (5)
C.B.	4.41 ± 1.21 (8)	7.3 ± 6.7 (8)	24 ±16 (5)	3.78 ± 1.5 (5)

TABLE 26. Summary of transparency, chlorophyll *a*, carbon fixation and assimilation ratio in all zones of the four lakes. Data for each parameter are given as the mean ± one standard deviation followed by the number of observations.

	Secchi disc	Chlorophyll	Carbon fixation	Assimilation ratio
Lake Superior				
Open lake	12.6 ± 3.4 (30)	0.66 ± 0.42 (27)	0.37 ± 0.18 (67)	0.82 ± 0.45 (15)
Bays	6.6 ± 1.1 (5)	1.46 ± 0.19 (5)	0.59 ± 0.14 (15)	
Lake Huron				
Open lake (I)	9.1 ± 2.4 (7)	0.81 ± 0.72 (7)	0.77 ± 0.38 (4)	1.26 ± 1.0 (4)
" " (II)	8.0 ± 2.4 (7)	0.86 ± 0.46 (8)	1.69 ± 0.51 (5)	2.67 ± 1.4 (5)
" " (III)	5.9 ± 0.62 (5)	0.86 ± 0.04 (4)	1.50 ± 0.53 (4)	1.76 ± 0.63 (4)
Bays (IV)	1.8 ± 0.40 (6)	7.26 ± 3.1 (6)	28 ±17 (5)	4.16 ± 2.5 (5)
Lake Michigan				
Open lake	4.8 ± 0.6 (6)	1.34 ± 0.62 (7)	2.40 ± 0.82 (13)	0.74
Lake Erie				
W.B.North	1.96 ± 0.43 (5)	3.65 ± 1.3 (5)	11 ± 5.1 (3)	3.75 ± 2.9 (3)
W.B.South	1.99 ± 0.53 (7)	12.1 ± 3.8 (7)	58 ±18 (5)	4.91 ± 0.78 (5)
C.B.	4.41 ± 1.21 (8)	7.3 ± 6.7 (8)	24 ±16 (5)	3.78 ± 1.5 (5)

2nd decimal not justified.

TABLE 2[illegible]. Summary of temperature and dissolved oxygen in all zones of the four lakes. Data for each parameter are given as the mean ± one standard deviation followed by the number of observations in parenthesis.

	Temperature, °C		Dissolved Oxygen, ppm	
	Surface	Bottom	Surface	Bottom
Lake Superior				
Open Lake	8.4 ± 3.7 (30)	3.82 ± 0.36 (29)	12.5 ± 0.87 (20)	13.1 ± 0.46 (20)
Bays	14.1 ± 1.2 (5)	4.45 ± 0.64 (2)	10.8 ± 0.21 (4)	13.2 (1)
Lake Huron				
Open lake (I)	16.5 ± 1.2 (7)	4.62 ± 0.84 (5)	10.1 ± 0.37 (6)	11.5 ± 0.67 (5)
Open lake (II)	18.5 ± 1.6 (8)	4.68 ± 0.82 (5)	9.51 ± 0.27 (8)	11.8 ± 0.20 (5)
Open lake (IV)	20.6 ± 0.9 (5)	13.9 ± 2.7 (10)	9.40 ± 0.20 (5)	10.0 ± 0.26 (10)
Saginaw Bay (III)	22.7 ± 1.1 (6)	16.5 ± 2.7 (6)	9.58 ± 0.50 (6)	9.35 ± 0.48 (6)
Lake Michigan				
Open lake	14.2 ± 1.2 (6)	4.10 ± 0.14 (2)	10.1 ± 1.4 (2)	12.5 (1)
Lake Erie				
W. B. North (I)	24.0 ± 0.9 (5)	22.6 ± 0.8 (5)	8.62 ± 0.49 (4)	7.60 ± 0.6 (5)
W. B. South (II)	24.4 ± 0.4 (7)	23.0 ± 1.1 (7)	8.13 ± 0.76 (7)	7.20 ± 1.4 (7)
C. B. (III)	24.9 ± 0.5 (8)	16.3 ± 5.2 (8)	9.56 ± 0.58 (8)	5.15 ± 2.3 (8)

Table 2. Summary of silica, nitrate nitrogen and particulate phosphorus in all zones of the four lakes. Data for each parameter are given as the mean ± one standard deviation followed by the number of observations in parenthesis.

	~~Silica~~ SiO_2, ppm		~~Nitrate~~ NO_3-N, ppb		-Sestonic Phosphorus PO_4, ppb	
	Surface	Bottom	Surface	Bottom	Surface	Bottom
Lake Superior						
Open lake	2.28 ± 0.07 (25)	2.28 ± 0.21 (23)	254 ± 14 (25)	264 ± 7.7 (23)	8.7 ± 6.7 (23)	9.4 ± 16 (23)
Bays	2.10 ± 0.13 (5)	2.31 ± 0.01 (2)	229 ± 11 (5)	263 ± 2.1 (2)	5.6 ± 4.5 (4)	4.6 ± 5 (2)
Lake Huron						
Open lake (I)	1.07 ± 0.15 (7)	1.80 ± 0.16 (5)	139 ± 31 (7)	159 ±33 (5)	13 ± 0.8 (2)	41 (1)
Open lake (II)	0.81 ± 0.15 (8)	1.78 ± 0.19 (5)	141 ± 24 (8)	190 ±52 (5)	19 ±23 (7)	11 ± 14 (4)
" " (IV)	0.65 ± 0.11 (5)		136 ± 35 (5)		12 ± 5.4 (5)	
Saginaw Bay	1.08 ± 0.26 (6)		21 ± 16 (6)		37 ±19 (6)	
Lake Michigan						
Open lake	0.27 ± 0.05 (4)	1.28 ± 0.08 (2)	129 ± 6 (4)	190 ± 4 (2)	8 ±10 (2)	12 ± 0.5 (2)
Lake Erie						
W.B.North	0.97 ± 0.12 (4)	1.24 ± 0.35 (5)	79 ± 64 (4)	106 ±52 (5)	12 ± 4.8 (4)	18 ± 7.8 (3)
W.B.South	0.66 ± 0.26 (7)	0.85 ± 0.20 (7)	86 ± 33 (7)	125 ±51 (7)	53 ±24 (6)	53 ± 31 (7)
C.B.	0.25 ± 0.10 (8)	1.36 ± 0.76 (8)	34 ± 24 (8)	103 ±57 (8)	15 ±15 (5)	39 ± 54 (3)

Bottom is the depth interval from 72-390 m in Lake Superior,
" " " " " " 32-80 m in Lake Huron,
" " " " " " 110-125 m in Lake Michigan.

TABLE 27. Summary of pH, alkalinity, conductivity, calcium, sulfate and chloride in all zones of the four lakes. Data for each parameter are given as the mean ± one standard deviation followed by the number of observations in parenthesis.

	pH	Alkalinity, ppm	Conductivity, micro mho/cc.	Calcium, ppm	Sulfate, ppm	Chloride, ppm
ke Superior						
Open lake	8.04 ± 0.10 (87)	43.9 ± 1.8 (85)	95 ± 4.8 (30)	14.5 ± 1.6 (68)	1.46 ± 0.41 (57)	1.06 ± 0.08 (70)
Bays	8.01 ± 0.26 (19)	41.9 ± 2.4 (19)	93 ± 3.0 (5)	14.7 ± 0.9 (15)	1.85 ± 0.49 (13)	1.13 ± 0.10 (15)
ke Huron						
Open lake (I)	8.50 ± 0.04 (7)	76.8 ± 1.9 (25)	192 ± 8.0 (7)	21.2 ± 1.7 (21)		4.65 ± 1.5 (21)
Open lake (II)	8.38 ± 0.16 (24)	76.5 ± 6.7 (24)	195 ± 5.7 (8)	26.5 ± 0.6 (24)	10 (1)	5.58 ± 0.94 (23)
Open lake (IV)	8.40 ± 0.06 (15)	82.5 ± 1.2 (15)	204 ± 2.7 (5)	28.0 ± 0.8 (13)	10.9 ± 0.72 (12)	6.6 ± 1.4 (16)
Saginaw Bay (III)	8.65 ± 0.17 (18)	88.6 ± 3.7 (18)	247 ±20 (6)	30.3 ± 1.7 (18)	12.8 ± 1.8 (5)	10.6 ± 2.3 (18)
ke Michigan						
Open lake	8.50 ± 0.16 (19)	109 ± 2.8 (19)	261 (1)	37.4 ± 1.6 (17)	15.5 ± 3.0 (17)	7.22 ± 0.32 (16)
ke Erie						
W. B. North (I)	8.63 ± 0.25 (5)*	83.7 ± 2.1 (14)	257 ±11 (4)	31.6 ± 1.2 (10)	11.8 ± 0.84 (14)	14.3 ± 1.3 (24)
W. B. South (II)	8.82 ± 0.11 (7)*	88.1 ± 2.9 (21)	246 ± 7 (2)	32.7 ± 1.6 (14)	16.7 ± 2.4 (16)	13.2 ± 0.5 (20)
C. B. (III)	8.93 ± 0.06 (8)*	92.5 ± 2.5 (24)	293 ± 9 (8)	37.8 ± 1.2 (16)	21.6 ± 3.3 (16)	14.6 ± 1.6 (24)

Appendix Table I. Location, depth (meters), date, and time (Eastern Standard Time, Hours), for each station, 1970 Great Lakes Limnology cruises.

STA. NO.	LOCATION		DEPTH	DATE	TIME
LM70- 1	44° 42.9' N	86° 16.9' W	42.7	July 7	0650
LM70- 2	44 54.6	86 08.7	12.2	July 7	0838
LM70- 3	45 00.2	85 59.4	37.2	July 7	0947
LM70- 4	45 15.3	85 46.7	149.3	July 7	1154
LM70- 5	45 32.8	85 30.5	114.0	July 7	1440
LM70- 6	45 44.2	85 26.1	13.0	July 7	1634
		Lake Superior			
SU70- 1	46 41.5	84 29.0	24.4	July 9	0617
SU70- 2	46 40.5	84 37.5	77.7	July 9	0722
SU70- 3	46 47.0	84 41.0	20.4	July 9	0829
SU70- 4	46 52.3	84 44.7	103.6	July 9	0925
SU70- 5	47 00.7	84 51.0	152.4	July 9	1048
SU70- 6	47 00.8	84 53.3	11.9	July 9	1130
SU70- 7	47 06.7	85 09.3	192.0	July 9	1252
SU70- 8	47 21.1	85 46.4	88.4	July 9	1622
SU70- 9	47 26.1	85 47.7	17.4	July 9	1721
SU70-10	47 39.8	85 47.9	169.2	July 9	1858
SU70-15	47 41.0	85 50.8	135.6	July 10	0628
SU70-16	47 39.2	86 08.4	181.3	July 10	0802
SU70-17	47 37.5	86 26.2	184.4	July 10	0946
SU70-18	47 36.0	86 44.5	274.3	July 10	1131
SU70-19	47 34.0	87 03.0	320.0	July 10	1327
SU70-20	47 32.5	87 21.0	215.8	July 10	1520
SU70-21	47 31.2	87 38.7	140.8	July 10	1702
SU70-22	47 29.1	87 49.2	94.8	July 10	1914
SU70-23	47 23.6	87 46.9	35.0	July 11	0717
SU70-25	47 14.4	87 20.8	166.1	July 11	0912
SU70-26	47 10.3	87 13.8	53.3	July 11	1022
SU70-27	47 02.7	86 55.3	177.7	July 11	1211
SU70-28	46 54.6	86 35.8	396.8	July 11	1412
SU70-29	46 44.8	86 39.2	204.2	July 11	1610
SU70-30	46 32.8	86 43.3	32.3	July 11	1747

Appendix Table A (Continued)

STA. NO.	LOCATION		DEPTH	DATE	TIME
SU70-31	46° 25.5' N	86° 38.3' W	25.0	July 11	1857
SU70-32	46 34.0	86 30.4	96.0	July 12	0603
SU70-33	46 33.6	86 26.3	18.3	July 12	0648
SU70-34	46 34.7	86 23.4	20.4	July 12	0714
SU70-35	46 40.6	86 21.0	123.4	July 12	0801
SU70-36	46 41.0	86 09.8	21.9	July 12	0907
SU70-37	46 44.4	86 00.0	25.9	July 12	1007
SU70-38	46 45.0	85 30.0	131.1	July 12	1147
SU70-39	46 46.5	85 14.5	17.4	July 12	1355
SU70-40	46 47.2	84 58.5	15.2	July 12	1518
		Lake Huron			
HU70- 1	45 41.1	84 15.6	24.7	July 27	0705
HU70- 2	45 39.6	84 05.3	57.0	July 27	0803
HU70- 3	45 38.1	83 51.3	86.9	July 27	0920
HU70- 4	45 27.8	83 27.0	86.9	July 27	1139
HU70- 5	45 19.0	83 20.2	57.3	July 27	1255
HU70- 6	45 07.6	83 11.0	10.7	July 27	1425
HU70- 7	45 01.3	83 06.0	38.1	July 27	1524
HU70- 8	45 00.0	83 19.0	16.1	July 28	0640
HU70- 9	44 55.2	83 13.7	36.0	July 28	0731
HU70-10	44 49.5	83 06.6	57.3	July 28	0831
HU70-11	44 42.8	82 59.2	70.1	July 28	0944
HU70-12	44 30.2	83 00.7	66.1	July 28	1116
HU70-13	44 23.7	83 09.6	48.8	July 28	1218
HU70-14	44 18.0	83 17.0	20.4	July 28	1328
HU70-15	44 14.2	83 30.0	8.5	July 28	1444
HU70-16	44 07.5	83 31.8	10.7	July ~~28~~ 29	0705
HU70-17	43 58.0	83 36.3	12.2	July 29	0820
HU70-18	43 49.6	83 43.5	8.5	July 29	0928
HU70-19	43 53.5	83 36.5	11.0	July 29	1020
HU70-20	43 58.8	83 32.2	10.7	July 29	1112
HU70-21	44 06.6	83 24.9	10.7	July 29	1234
HU70-22	44 06.5	83 04.0	25.9	July 29	1418
HU70-23	43 41.8	82 32.8	20.4	July 30	0701

Appendix Table X. (Concluded)

STA. NO.	LOCATION		DEPTH	DATE	TIME
HU70-24	43° 31.1' N	82° 30.4' W	23.2	July 30	0821
HU70-25	43 20.0	82 28.1	20.7	July 30	0940
HU70-26	43 09.8	82 25.7	16.1	July 30	1104
		Lake Erie			
ER70- 1	41 57.2	83 05.5	9.1	July 31	1311
ER70- 2	41 57.0	82 58.7	9.5	July 31	1401
ER70- 3	41 57.3	82 52.2	9.7	July 31	1453
ER70- 4	41 50.7	82 52.7	10.7	July 31	1604
ER70- 5	41 45.3	82 52.5	10.0	July 31	1655
ER70- 6	41 39.8	82 52.1	9.7	July 31	1757
ER70- 7	41 39.0	82 36.8	14.6	August 1	0740
ER70- 8	41 38.6	82 27.5	12.5	August 1	0840
ER70- 9	41 38.2	82 15.0	15.2	August 1	0947
ER70-10	41 37.7	82 03.4	18.6	August 1	1058
ER70-11	41 35.0	82 04.9	16.1	August 1	1152
ER70-12	41 32.7	82 08.4	10.0	August 1	1240
ER70-13	41 28.8	82 23.4	14.6	August 1	1341
ER70-14	41 29.8	82 37.8	12.2	August 1	1500
ER70-15	41 44.7	82 53.8	10.7	August 2	0644
ER70-16	41 48.0	83 02.2	10.4	August 2	0743
ER70-17	41 49.0	83 10.6	7.3	August 2	0846
ER70-18	41 45.7	83 .8.2	7.3	August 2	0947
ER70-19	41 48.8	83 14.9	7.9	August 2	1032
ER70-20	41 54.1	83 09.4	7.9	August 2	1128

Appendix Table II. Physical and chemical data collected during the ~~1970~~ Study ~~Great Lakes Limnology cruises~~.

Abbreviations used in Appendix Table II

STA NO - Station number

DEPTH - Depth, m

TEMP - Temperature, °C

DISC - Secchi disc, m

COND - Conductivity, μmho

D.O. - Dissolved oxygen, ppm

PH - pH

ALK - Methyl orange alkalinity, ppm $CaCO_3$

CA - Calcium, ppm

PO4 - Orthophosphate phosphorus, ppb

NO3 - Nitrate, ppb

NH3 - Ammonia, ppb

CL - Chloride, ppm

SO4 - Sulfate, ppm

SIO2 - Silica, ppm

CHL - Chlorophyll a, ppb

LAKE SUPERIOR

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
SU70- 1	0	13.5	6.0	96	10.8	7.90	42.0	14.0	4.0	233	9	1.2	2.8	2.02	1.6
SU70- 1	8	12.0				8.16	41.0	13.4	1.0	226	10	1.0	1.8	1.98	
SU70- 1	12	9.5						14.0		232	7	1.1	2.6	2.05	
SU70- 1	22	7.0			12.6	7.76	43.0	13.8	1.0	243	14	1.1	2.0	2.17	
SU70- 2	0	15.1	5.5	88		7.82	40.0	14.2	3.0	215	11	1.3	2.4	2.30	
SU70- 2	3	15.0				8.19	43.0								1.2
SU70- 2	6	14.0				8.01	42.0								
SU70- 2	22	9.0			12.0	7.85	42.0	15.0		234	13	1.1	1.7	2.08	
SU70- 2	72	4.9						15.0	2.0	261	14	1.0	1.9	2.32	
SU70- 3	0	13.0	8.0	94	10.8	8.08	44.0	16.2	4.0	241	15	1.3	1.9	1.98	
SU70- 3	3	13.0				8.09	42.0								1.4
SU70- 3	6	13.0				8.16	42.0								
SU70- 3	12	10.0			11.6	7.09	34.0	15.0		246	8	1.1	1.3	2.25	
SU70- 3	19	7.5				8.10	44.0	15.8	5.0	249	11	1.1	1.5	2.25	
SU70- 4	0	13.2	7.5	94	10.6	8.13	41.0	15.4	5.0	235	7	1.1	1.3	2.03	
SU70- 4	3	13.0				8.19	43.0								1.7
SU70- 4	6	13.0				8.19	41.0								
SU70- 4	12	11.0			12.2	8.17	40.0	15.8	1.0	239	13	1.1	1.3	2.18	
SU70- 4	99	4.0			13.2	7.93	42.0	15.4	6.0	264	11	1.1	1.6	2.30	
SU70- 5	0	11.2	9.0	96				16.7	1.0	244	14	1.1	1.0	2.24	
SU70- 5	3	11.0			11.4	8.12	42.0								0.9
SU70- 5	6	11.0													
SU70- 5	15	8.5			12.8	8.11	41.0	15.2		245	8	1.0	1.3	2.22	
SU70- 5	155	3.5			13.8	7.99		15.5	2.5	256	11	1.1	1.4	2.26	
SU70- 6	0	10.2	10.0	93				15.8	1.0	253		1.0	1.4	2.26	1.2
SU70- 6	3	10.0			11.8	8.12	41.0								
SU70- 6	6	9.0				8.12	42.0								
SU70- 6	9	7.2			12.6	8.19	41.0								
SU70- 6	11	6.5													
SU70- 7	0	3.5	15.0	94	13.2	8.02	38.0	16.2		262	10	1.1	1.2	2.32	

LAKE SUPERIOR

TA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
U70- 1	0	13.5	6.0	96	10.8	7.90	42.0	14.0	4.0	233	9	1.2	2.8	2.02	1.6
U70- 1	8	12.0				8.16	41.0	13.4	1.0	226	10	1.0	1.8	1.98	
U70- 1	12	9.5						14.0		232	7	1.1	2.6	2.05	
U70- 1	22	7.0			12.6	7.76	43.0	13.8	1.0	243	14	1.1	2.0	2.17	
U70- 2	0	15.1	5.5	88		7.82	40.0	14.2	3.0	215	11	1.3	2.4	2.30	
U70- 2	3	15.0				8.19	43.0								1.2
U70- 2	6	14.0				8.01	42.0								
U70- 2	22	9.0			12.0	7.85	42.0	15.0		234	13	1.1	1.7	2.08	
U70- 2	72	4.9						15.0	2.0	261	14	1.0	1.9	2.32	
U70- 3	0	13.0	8.0	94	10.8	8.08	44.0	16.2	4.0	241	15	1.3	1.9	1.98	
U70- 3	3	13.0				8.09	42.0								1.4
U70- 3	6	13.0				8.16	42.0								
U70- 3	12	10.0			11.6	7.09	34.0	15.0		246	8	1.1	1.3	2.25	
U70- 3	19	7.5				8.10	44.0	15.8	5.0	249	11	1.1	1.5	2.25	
U70- 4	0	13.2	7.5	94	10.6	8.13	41.0	15.4	5.0	235	7	1.1	1.3	2.03	
U70- 4	3	13.0				8.19	43.0								1.7
U70- 4	6	13.0				8.19	41.0								
U70- 4	12	11.0			12.2	8.17	40.0	15.8	1.0	239	13	1.1	1.3	2.18	
U70- 4	99	4.0			13.2	7.93	42.0	15.4	6.0	264	11	1.1	1.6	2.30	
U70- 5	0	11.2	9.0	96				16.7	1.0	244	14	1.1	1.0	2.24	
U70- 5	3	11.0			11.4	8.12	42.0								0.9
U70- 5	6	11.0													
U70- 5	15	8.5			12.8	8.11	41.0	15.2		245	8	1.0	1.3	2.22	
U70- 5	155	3.5			13.8	7.99		15.5	2.5	256	11	1.1	1.4	2.26	
U70- 6	0	10.2	10.0	93				15.8	1.0	253		1.0	1.4	2.26	1.2
U70- 6	3	10.0			11.8	8.12	41.0								
U70- 6	6	9.0				8.12	42.0								
U70- 6	9	7.2			12.6	8.19	41.0								
U70- 6	11	6.5													
U70- 7	0	3.5	15.0	94	13.2	8.02	38.0	16.2		262	10	1.1	1.2	2.32	

STA NO	DEPTH	TEMP	DISC COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
						LAKE MICHIGAN								
LM70- 1	0	14.9	5.0		8.56	109.0	36.0	7.0	133	14	7.6	15.0	0.33	
LM70- 1	10	14.8			8.55	110.0	38.5	7.0				16.5		
LM70- 1	15	13.0			8.55	118.0	36.0	5.0	127	18	7.8	14.5	0.34	
LM70- 1	25	10.5			8.54	110.0	36.0	1.0	156	21	7.3	14.0	0.53	
LM70- 1	40	7.0			8.39	109.0	37.5	1.0	174	23	7.2	12.5	1.00	
LM70- 2	0	14.0	4.0		8.63	110.0	35.0	7.0	127	30	7.2	13.0	0.22	1.80
LM70- 2	6	13.9			8.63	110.0	36.0	7.0	147	14	7.8	15.0	0.27	
LM70- 2	11	13.7												
LM70- 3	0	13.5	4.0											2.1
LM70- 3	2	13.5			8.61	110.0								
LM70- 3	5	13.4					38.5	5.0	131	20	6.9	13.0	0.39	
LM70- 3	10	13.4												1.7
LM70- 3	15	13.0		10.1										
LM70- 3	20	12.5		9.0			37.5	12.0	144	12	7.6	11.0	0.26	
LM70- 3	30	9.0			8.44	110.0								
LM70- 3	40	7.0			8.38	112.0	38.5	7.0	176	23	7.2	14.5	0.98	
LM70- 4	0	12.5	5.0	11.1			37.5	5.0	134	5	7.0	17.5	0.28	
LM70- 4	10	12.4			8.63	110.0								
LM70- 4	25	8.0		12.4	8.54	108.0	37.0	1.0	143	9	7.0	15.0	0.47	1.7
LM70- 4	40	5.5												
LM70- 4	125	4.0		12.5	8.29	106.0	40.0	1.0	187	20	6.9	14.5	1.23	
LM70- 5	0	14.5	5.5	9.1	8.66	109.0	34.5	1.0	121	13	7.2	14.5	0.27	0.7
LM70- 5	10	14.0		9.5	8.49	108.0							0.17	0.7
LM70- 5	25	9.7		10.0	8.48	107.0	38.5	5.0	146	18	7.2	21.0	0.35	
LM70- 5	110	4.2			8.00	106.0	33.5	11.0	193	25	6.9	21.5	1.34	
LM70- 6	0	16.0	5.0											0.7
LM70- 6	2	15.7					39.5		117	15	6.8	20.0	0.29	
LM70- 6	4	15.5		10.3	8.58	106.0								
LM70- 6	8	15.0		10.4	8.46	106.0								
LM70- 6	13	14.5												

LAKE SUPERIOR

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
SU70- 1	0	13.5	6.0	96	10.8	7.90	42.0	14.0	4.0	233	9	1.2	2.8	2.02	1.6
SU70- 1	8	12.0				8.16	41.0	13.4	1.0	226	10	1.0	1.8	1.98	
SU70- 1	12	9.5						14.0		232	7	1.1	2.6	2.05	
SU70- 1	22	7.0			12.6	7.76	43.0	13.8	1.0	243	14	1.1	2.0	2.17	
SU70- 2	0	15.1	5.5	88		7.82	40.0	14.2	3.0	215	11	1.3	2.4	2.30	
SU70- 2	3	15.0				8.19	43.0								1.2
SU70- 2	6	14.0				8.01	42.0								
SU70- 2	22	9.0			12.0	7.85	42.0	15.0		234	13	1.1	1.7	2.08	
SU70- 2	72	4.9						15.0	2.0	261	14	1.0	1.9	2.32	
SU70- 3	0	13.0	8.0	94	10.8	8.08	44.0	16.2	4.0	241	15	1.3	1.9	1.98	
SU70- 3	3	13.0				8.09	42.0								1.4
SU70- 3	6	13.0				8.16	42.0								
SU70- 3	12	10.0			11.6	7.09	34.0	15.0		246	8	1.1	1.3	2.25	
SU70- 3	19	7.5				8.10	44.0	15.8	5.0	249	11	1.1	1.5	2.25	
SU70- 4	0	13.2	7.5	94	10.6	8.13	41.0	15.4	5.0	235	7	1.1	1.3	2.03	
SU70- 4	3	13.0				8.19	43.0								1.7
SU70- 4	6	13.0				8.19	41.0								
SU70- 4	12	11.0			12.2	8.17	40.0	15.8	1.0	239	13	1.1	1.3	2.18	
SU70- 4	99	4.0			13.2	7.93	42.0	15.4	6.0	264	11	1.1	1.6	2.30	
SU70- 5	0	11.2	9.0	96				16.7	1.0	244	14	1.1	1.0	2.24	
SU70- 5	3	11.0			11.4	8.12	42.0								0.9
SU70- 5	6	11.0													
SU70- 5	15	8.5			12.8	8.11	41.0	15.2		245	8	1.0	1.3	2.22	
SU70- 5	155	3.5			13.8	7.99		15.5	2.5	256	11	1.1	1.4	2.26	
SU70- 6	0	10.2	10.0	93				15.8	1.0	253		1.0	1.4	2.26	1.2
SU70- 6	3	10.0			11.8	8.12	41.0								
SU70- 6	6	9.0				8.12	42.0								
SU70- 6	9	7.2			12.6	8.19	41.0								
SU70- 6	11	6.5													
SU70- 7	0	3.5	15.0	94	13.2	8.02	38.0	16.2		262	10	1.1	1.2	2.32	

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
SU70-19	150	3.8				7.98	44.0	14.2		274	5	1.0		2.36	
SU70-19	300	3.7			13.2	7.97	44.0	14.2	1.1	269	11	1.0	1.5	1.37	
SU70-20	0	5.3	19.0	95											
SU70-20	50	4.5													
SU70-20	150	4.1													
SU70-20	215	4.0													
SU70-21	0	8.0	12.5	91	13.2	8.07	45.0	15.0	1.0	250	6	1.0	1.9	2.29	
SU70-21	3	7.5				8.07	46.0								0.2
SU70-21	50	5.0			13.0	7.97	44.0	15.0		255	5	1.0	1.9	2.30	
SU70-21	140	3.8			12.9	7.97	45.0	15.0	1.0	268	6	1.0	1.5	2.37	
SU70-22	0	15.3	9.0	92											0.6
SU70-22	10	15.0													
SU70-22	20	11.0													
SU70-22	35	9.0													
SU70-22	90	4.0													
SU70-23	0	14.0	9.0	94	10.8	8.08	44.0								0.7
SU70-23	3	14.5						16.0	1.0	242	8	1.1	2.5	2.28	
SU70-23	15	11.6			11.9	8.09	46.5	15.5		251	9	1.0		2.24	
SU70-23	30	8.5			11.8	8.05	45.4	15.5	1.0	255	20	1.1	1.9	2.31	
SU70-25	0	7.5	14.0	101		8.07	45.7	13.5	1.0	257	6	1.0	1.9	2.31	
SU70-25	3	7.0			12.0	8.03	45.2								0.4
SU70-25	75	4.0				7.98	44.8	13.5	1.0	262	6	1.0		2.36	
SU70-25	150	3.7			11.9	7.95	47.2	13.5	1.0	268	11	1.0	1.9	2.29	
SU70-26	0	7.5	15.0	89		8.04	45.5	13.5	1.5	259	9	1.0	1.5	2.31	
SU70-26	3	6.3				8.04	44.5								0.3
SU70-26	25	5.0						17.5	1.5	266	6	1.0		2.28	
SU70-26	50	4.9				8.07	47.5	9.5	1.0	263	10	1.0	1.6	2.29	
SU70-27	0	6.8	16.5	92	13.1	8.06	46.2	10.5	1.0	268	6	1.0	2.2	2.36	
SU70-27	3	4.4													0.3
SU70-27	85	3.9			13.0	8.01	45.3	13.5	1.0	263	7	1.0		2.31	
SU70-27	165	3.5			13.1			13.7	1.0	264	6	1.0	1.3	2.36	
SU70-28	0	5.5	15.0	94		8.02	44.3	13.5	1.5	276	10	1.0	2.5	2.34	

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
SU70-28	3	4.3			13.1	8.07									
SU70-28	90	3.8			13.0	7.97	45.3								
SU70-28	390	3.7			13.0	7.96	44.8	13.7	5.0	265	9	1.0	1.9	2.29	
SU70-29	0	9.0	14.0	94	12.7	8.05	45.3	13.5	1.0	266	14	1.0	1.5	2.28	0.1
SU70-29	3	9.0													
SU70-29	90	3.8			12.9	8.01	46.2	13.7		268	7	1.0		2.29	
SU70-29	180	3.5			13.0	7.98	46.2	13.5	1.0	258	7	1.0	1.9	2.32	
SU70-30	0	12.2	8.5	99	11.5	8.23	46.7	13.7		224	10	1.2	1.2	2.18	
SU70-30	3	12.0				8.22	45.4								0.6
SU70-30	30	9.2			12.3	8.14	47.0	15.5		237	6	1.2	1.7	2.30	
SU70-31	0	15.5	6.0	94	11.1	8.23	45.3	13.7	1.0	222	69	1.3		2.17	1.4
SU70-31	3	15.5													
SU70-31	22	8.5			11.9	8.10	45.1	13.5	1.0	240	9	1.1		2.23	
SU70-32	0	12.5	10.0	91	11.5	8.10	44.6	9.0		229	10	1.2	0.9	2.21	
SU70-32	3	11.5													
SU70-32	10	10.5			12.4										
SU70-32	90	4.8			12.2	8.0	44.6	14.0		243	10	1.2	0.6	2.35	
SU70-33	0	12.0	9.0	94	12.2	8.15	43.6	14.0		233	5	1.2	1.3	2.23	0.5
SU70-33	3	11.0													
SU70-33	18	9.3			12.4	8.14	45.4	13.0		240	5	1.2	1.2	2.29	
SU70-34	0	13.5	9.0	96											
SU70-34	7	11.0													
SU70-34	14	10.0													
SU70-35	0	8.5	12.0	110	12.6	8.13	43.9			254	12	1.1		2.28	
SU70-35	3	8.0													0.6
SU70-35	25	6.2			13.0	8.04	44.5	14.8		248	6	1.1	1.3	2.41	
SU70-35	115	4.0			13.9	8.00	45.0	13.0		259	6	1.1	1.2	2.47	
SU70-36	0	12.5	13.5	95	11.4	7.97	45.1	13.0		252	10	1.1	1.8	2.17	
SU70-36	3	10.5													0.2
SU70-36	10	9.0			13.0	7.95	43.6							2.21	
SU70-36	19	7.5			12.8	8.17	43.8	11.6		246	5	1.0	1.2	2.26	
SU70-37	0	10.0	14.0	108	12.6	8.07	42.6	16.0		256	6	1.0	1.2	2.23	

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
SU70-37	3	7.6													0.3
SU70-37	10	7.1			13.0	8.06	41.6	15.0		252	5	1.0	1.2		
SU70-37	20	6.8			13.2	8.06	42.2	16.0		253	6	1.0	1.4	2.26	
SU70-38	0	7.5	14.0	93	13.2	8.00	42.6	13.0		261	10	1.2	1.2	2.45	
SU70-38	3	6.8													0.2
SU70-38	30	4.4			12.8	7.97	42.4	13.0		258	5	1.2	0.6	2.40	
SU70-38	120	4.0			13.4	7.95	42.2	15.0		257	7	1.2	1.7	2.47	
SU70-39	0	13.0	9.0	94	11.2	8.22	43.7	13.0		227	5	1.0	1.2	2.17	
SU70-39	3	12.0													0.5
SU70-39	10	11.5			12.0	8.22	44.6	15.0		235	5	1.2	1.3	2.28	
SU70-39	15	10.6			12.4	8.25	43.8	16.0		236	11	1.2	1.7	2.40	
SU70-40	0	12.4	9.0	102	11.2	8.21	43.7	13.0		232	9	1.2		2.28	
SU70-40	3	11.1			11.2	8.14	43.6	15.0		228	6	1.1		2.28	
SU70-40	12	10.0			11.8	8.13	42.2	15.0				1.1		2.23	

LAKE HURON

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
HU70- 1	0	18.0	6.0	196		8.54	80.0	19.7		134	12	5.6		1.16	
HU70- 1	3	17.5													0.40
HU70- 1	12	14.0			10.7		72.0	19.4		158		4.0		1.29	
HU70- 1	20	12.0			12.0		75.0	18.0		143	15	9.6		1.29	
HU70- 2	0	16.5	8.0	182	10.0	8.51	75.0	17.5		146	9	4.2		1.21	
HU70- 2	3	15.0													2.40
HU70- 2	20	11.0			10.7		74.5	20.1		161	12	4.4		1.24	
HU70- 2	55	4.5			11.0		77.0	22.7		148	13	3.6		1.83	
HU70- 3	0	15.0	9.0	180	10.2	8.53	74.5	20.1		163	21	4.7		1.20	
HU70- 3	3	15.0					74.3								0.64
HU70- 3	15	8.0			11.9		74.5	21.3		106	11	3.5		1.38	
HU70- 3	80	4.0			12.2		77.0	22.0		151	12	3.9		1.88	
HU70- 4	0	15.0	10.0	198	10.5	8.49	76.3	22.5		175	13	5.6		1.08	
HU70- 4	3	15.0			10.8		76.2								0.40
HU70- 4	15	10.0			11.0		75.6	21.6		158	7	4.9		1.00	
HU70- 4	80	3.9			11.9		79.3	22.8		218	18	5.7		1.95	
HU70- 5	0	16.5	13.0	191	10.2	8.47	78.0	19.3	0.5	88	10	2.6		1.08	
HU70- 5	3	16.2			10.2		75.6								0.40
HU70- 5	20	11.5			10.0		77.4	20.1	0.5	108	11	3.0		1.24	
HU70- 5	50	4.7			10.6		78.1	22.0	1.0	134	14	3.6		1.78	
HU70- 6	0	16.2	11.0	199	10.0	8.49	79.0	22.1	3.5	155	22	5.8		1.00	
HU70- 6	3	16.0			10.1		78.0	22.8	1.5	111	10	3.6		0.94	0.64
HU70- 6	8	12.0			10.8		76.7	22.5	1.0	163	12	5.5		1.08	
HU70- 7	0	18.0	7.0	198	9.4	8.44	78.6	23.5	3.5	110	8	3.9		0.77	
HU70- 7	3	17.9			9.6		78.1								0.80
HU70- 7	15	12.4			10.6		75.0	22.2	10.0	178	9	5.7		1.07	
HU70- 7	32	6.0			11.8		76.6	22.8	0.0	145	12	4.2		1.54	
HU70- 8	0	19.5	6.0	199	9.4	8.46	82.0	26.4	3.3	136	11	5.5		0.62	
HU70- 8	3	19.5													1.0
HU70- 8	8	15.0			10.8	8.39	59.5	25.5		171	13	5.4		1.05	

STA NO	DEPTH	TEMP	DISC	CCND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
HU70- 8	14	11.5			10.7	8.28	60.0	25.5	2.0	183	15	5.7		1.21	
HU70- 9	0	16.8	10.0	192	9.7	8.37	78.0	26.6	1.0	105	22	3.8		0.94	
HU70- 9	3	16.8													
HU70- 9	20	11.0			11.2	8.33	78.5	26.4		128	42	3.8		1.22	0.44
HU70- 9	33	6.0			11.6	8.20	80.0	26.6	1.3	98		3.1		1.47	
HU70-10	0	17.1	9.0	193	9.8	8.46	81.0	26.4	1.8	163	18	5.2		0.97	
HU70-10	3	16.8													
HU70-10	20	10.4			11.8	8.45	79.0	25.7		128	31	5.7		1.16	0.68
HU70-10	55	4.8			12.1	8.16	80.0	25.5	4.8	213	25	5.9		1.74	
HU70-11	0	17.4	7.0	189	9.9	8.48	78.5	26.7	2.3	161	30	5.4		0.84	
HU70-11	3	16.8													
HU70-11	20	10.7			11.2	8.48	78.0	26.4		181	19	5.8		1.12	1.2
HU70-11	65	4.1			11.8	8.15	76.5	27.0	2.5	200	38	5.6		1.95	
HU70-12	0	16.9	12.0	188	9.5	8.47	77.5	26.8	2.0	173		5.5		0.98	
HU70-12	3	16.3													
HU70-12	20	9.3			12.0	8.47	64.5	26.5		153	28	5.8		1.10	0.40
HU70-12	60	3.9			11.8	8.12	70.5	27.0	5.0	223	32	5.9		1.85	
HU70-13	0	20.0	5.5	193	9.4	8.52	82.0	26.9	3.3	143		7.2		0.65	
HU70-13	3	18.5													
HU70-13	20	13.0			10.4	8.43	72.5	25.6							1.0
HU70-13	46	4.6			11.6	8.08	79.0	26.4	2.3	218	32	5.9		1.87	
HU70-14	0	20.5		202	9.1	8.54	80.5	26.8	2.3	115	21	5.7		0.77	
HU70-14	3	17.5													
HU70-14	10	15.0			9.8	8.47	79.5	26.4		153	26	6.2		0.80	0.44
HU70-14	18	12.0			10.2	8.11	81.0	26.8	5.3	193	43	5.5		1.68	
HU70-15	0	19.8	6.5	203	9.3	8.60	83.5	27.4	2.8	128	18	6.9	10.0	0.69	
HU70-15	3	17.1			9.9	8.59	72.0	26.8		146	15	6.6		0.73	1.72
HU70-15	8	16.2			10.1	8.54	83.0	27.6	0.8	145	34	6.2		1.04	
HU70-16	0	21.0	2.5	223	10.1	8.59	84.8	29.7	4.4	48	22	10.3	12.0	0.84	
HU70-16	3	20.0			10.0	8.62	82.2	28.5		64	18	7.6		0.75	2.60
HU70-16	10	14.8			10.3	8.55	82.2	28.7	4.4	76	13	9.7		0.75	
HU70-17	0	22.0	1.5	266	8.9	8.68	93.1	32.8	6.5	10	19	11.2	14.0	1.37	
HU70-17	3	21.0			9.0	8.60	91.3	29.6		65	22	12.0		1.05	4.84

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
HU70-17	11	14.5			9.1	8.27	83.7	27.5	1.4	138	37	6.1		1.00	
HU70-18	0	23.9	1.5	263	9.1	8.88	89.0	32.0	5.1	8	14	12.8		1.35	
HU70-18	3	23.9			9.2	8.72	91.2	30.7		11	31	11.8		1.27	10.90
HU70-18	7	19.8			9.3	8.66	91.2	31.4	5.0	16	36	11.9		1.41	
HU70-19	0	23.5	1.5	266	9.5	8.78	93.5	31.8	2.8	10	23	13.8	15.2	1.13	
HU70-19	3	23.2			9.6	8.67	92.0	31.5		12	23	13.3		1.18	9.40
HU70-19	8	20.0			9.2	8.72	93.0	32.2	10.8	18	28	13.6		1.19	
HU70-20	0	22.8	1.8	238	9.9	8.83	88.5	30.9	0.5	18		10.9	11.8	1.08	
HU70-20	3	22.8			9.9	8.72	89.6	30.5		12		9.3		1.16	8.24
HU70-20	9	15.7			9.0	8.46	87.7	28.9	1.8	82	44	8.8		1.06	
HU70-21	0	23.1	2.0	227	10.0	8.76	87.8	31.6	20.0	33	22	10.2	10.8	0.73	
HU70-21	3	22.8			10.3	8.86	89.0	30.0		26	23	11.3		0.76	7.56
HU70-21	9	14.0			9.2	8.29	84.4	26.6	0.5	100	40	6.8		0.94	
HU70-22	0	21.5	7.0	199	9.4	8.41	81.8	29.3	4.2	153	34	6.0		0.82	
HU70-22	3	20.5						28.1		123	22	8.2		0.73	
HU70-22	15	13.9			10.2	8.39	80.8	29.0		123		3.7		0.95	
HU70-22	22	9.0			10.2	8.31	81.2	27.6	2.4	176	30	5.8		1.05	
HU70-23	0	20.0	5.5	206	9.6	8.45	82.5	27.5		144	19	7.3	10.5	0.57	
HU70-23	3	17.6													0.80
HU70-23	10	16.0			9.8	8.40	82.0	28.0		105	16	6.8	11.0	1.00	
HU70-23	15	12.2			9.8	8.33	82.8	27.5		161	22	7.1	11.1	1.14	
HU70-24	0	19.5	5.8	204	9.6	8.48	84.0	27.0		73	10	3.4	11.8	0.53	
HU70-24	3	18.5													0.88
HU70-24	10	16.0			9.6	8.36	82.8	27.5		161		7.3	11.5	0.83	
HU70-24	19	10.5			10.2	8.28	82.8			168	29	7.3	10.8	1.18	
HU70-25	0	20.5	5.5	205	9.2	8.46	83.6	28.5		153		7.4	11.8	0.63	
HU70-25	3	20.0													0.84
HU70-25	10	15.5			10.2	8.47	82.0			156	17	6.6	10.6	1.01	
HU70-25	18	13.0			10.4	8.45	82.0	29.0		175		6.0	9.5	1.15	
HU70-26	0	21.5	5.8	204	9.2	8.47	83.5	28.0		155	22	7.4	9.8	0.70	
HU70-26	3	21.0													0.88
HU70-26	10	17.2			9.8	8.44	81.0			158	10	8.5	11.3	0.70	
HU70-26	15	15.3			10.0	8.37	85.0	27.0		158	26	7.4	10.8	0.77	

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
							LAKE ERIE								
ER70- 1	0	22.8	2.0	261	8.0	8.40	80.1	32.0	7.0	143	39	14.0	10.7	1.00	
ER70- 1	2	22.1			8.2	8.37	83.0			156	28	13.9	11.2	1.06	2.24
ER70- 1	9	21.5			7.8	8.21	83.4	32.3	4.0	160	62	16.2	11.0	1.13	
ER70- 2	0	24.0	2.5	268	8.6	8.66	86.7	32.7	2.5	78	20	15.2	11.4	1.14	
ER70- 2	2	24.0			9.0	8.66	83.8			81	32	15.7	11.5	1.09	3.96
ER70- 2	9	23.5			7.6	8.43	85.2	32.0	9.0	86	75	15.0	11.2	1.33	
ER70- 3	0	25.0	2.0	256	8.7	8.86	84.3	32.0	1.5	49	37	15.0	12.0	0.86	
ER70- 3	2	25.0			8.6	8.85	84.0		1.5	46	39	15.0	12.5	0.87	4.24
ER70- 3	9	23.0			6.6	8.54	86.0	32.7	32.0	88		14.4	11.2	1.78	
ER70- 4	0	24.8	2.0	242	9.2	8.89	85.6	32.0	1.5	44	35	13.6	13.2	0.90	
ER70- 4	2	24.6			9.0	8.87	84.4		1.5	43	29	13.6	11.9	0.88	5.32
ER70- 4	9	22.1			8.2	8.76	84.7	31.0	8.0	40	42	13.2	11.5	0.83	
ER70- 5	0	25.0	2.5	241	8.8	8.88	86.3	30.5	15.8	56	35	12.9	12.7	0.40	
ER70- 5	2	24.8			9.2	8.92	86.7		4.0	48	28	12.6	14.0	0.36	7.84
ER70- 5	9	22.5			7.4	8.60	88.0	30.7	35.5	95	45	13.1	13.1	0.76	
ER70- 6	0	23.9	2.8	251	9.2	8.98	84.5	32.0	11.0	43	36	13.2	15.1	0.26	
ER70- 6	2	23.8			10.0	9.05	87.5			37	26	13.4	14.0	0.33	17.9
ER70- 6	7	22.5			4.4	8.24	96.8	36.5	52.0	195	37	14.1	18.5	1.22	
ER70- 7	0	24.5	3.0	286	9.4	8.90	93.0	36.5	7.0	85	63	14.7	25.0	0.30	
ER70- 7	2	24.5			9.4	8.89	93.0			66		13.1		0.22	7.44
ER70- 7	14	17.5			6.3	8.11	89.0	37.0	32.0	63	70	13.5	19.5	1.56	
ER70- 8	0	24.9	2.8	283	9.5	8.98	91.0	37.0	6.5	40	24	14.8	21.5	0.25	
ER70- 8	2	24.8			10.4	9.02	91.5			83	30	15.2		0.52	8.68
ER70- 8	13	15.0			7.1	8.27	91.0	38.0	15.1	63	46	14.0	21.5	0.81	
ER70- 9	0	24.3	6.0	293	9.3	8.90	91.5	38.5	17.5	49	19	13.8	21.5	0.30	
ER70- 9	2	24.2			9.4	8.90	90.5			61	15	15.7		0.30	1.96
ER70- 9	14	18.0			4.1	7.69	95.0	38.0	18.0	176	75	15.7	20.5	1.06	
ER70-10	0	24.5	5.5	300	9.0	8.86	91.0	39.5	18.0	13	19	16.0	21.0	0.14	
ER70-10	2	24.2			9.9	8.87	91.0			18	13	16.3		0.16	6.84
ER70-10	17	9.5			4.3	7.61	93.5	39.0	16.0	178	122	16.7	21.0	1.36	

STA NO	DEPTH	TEMP	DISC	COND	D.O.	PH	ALK	CA	PO4	NO3	NH3	CL	SO4	SIO2	CHL
ER70-11	0	24.8	5.5	300	9.3	8.85	93.5	38.5	15.1	13		15.7	21.5	0.16	
ER70-11	2	24.4			8.9	8.86	93.5			8	13	11.0		0.11	1.60
ER70-11	15	10.9			5.5	7.86	95.0	38.5	28.8	115		16.1	20.5	1.23	
ER70-12	0	25.5	3.5	286	10.0	9.01	88.5	37.0	3.5	18	13	15.5	21.0	0.17	
ER70-12	2	25.3			10.0	9.01	89.0			18	23	12.3		0.16	6.0
ER70-12	9	25.1			8.8	8.93	90.0	35.0	3.5	25	29	15.1	21.0	0.21	
ER70-13	0	25.4	4.5	287	9.2	8.97	94.0	38.0	14.3	26	14	15.5	19.5	0.25	
ER70-13	2	25.0			9.3	8.97	91.5			36	15	15.7		0.23	3.32
ER70-13	13	13.8			1.1	7.52	99.0	37.0	120.0	68	182	15.5	18.0	2.73	
ER70-14	0	25.4	4.5	310	10.8	8.99	94.0	40.0	13.8	31	13	10.7	32.5	0.46	
ER70-14	2	25.0			10.9	9.03	94.5			38	13	14.0		0.60	22.7
ER70-14	11	20.8			4.0	7.96	95.5	38.0	72.0	136	85	14.6	19.5	1.96	
ER70-15	0	24.1	1.5		6.8	8.64	88.1	32.5	20.5	109		13.4	16.5	0.93	
ER70-15	2	24.0			7.0		86.8			49	26	13.3		0.85	8.88
ER70-15	9	23.0			6.7		85.7	31.8	17.2	116	26	13.4	15.7	0.92	
ER70-16	0	23.8	2.0		7.8	8.80	88.8	31.8	19.0	85	34	13.0	17.7	0.88	
ER70-16	2	23.8			7.6		84.8			86	30	13.1		0.92	8.76
ER70-16	10	22.0			8.4		83.0	32.5	21.0	80	30	13.4	17.7	0.84	
ER70-17	0	24.2	1.8		8.0	8.79	88.1	34.0	27.3	113	53	13.5	20.8	0.64	
ER70-17	2	24.2			7.9		88.8			104	44	12.2		0.65	14.8
ER70-17	7	24.2			8.0		87.7	33.0	22.6	123	55	13.7	17.5	0.67	
ER70-18	0	24.3	1.3		8.1	8.88	89.3	35.0	31.8	65	64	13.3	17.5	0.91	
ER70-18	2	24.2			8.2		88.9			58	52	12.3		0.93	14.5
ER70-18	7	24.2			7.6		91.0	32.5	27.3	73		13.4	17.7	0.90	
ER70-19	0	24.3	2.0		8.2	8.74	91.0	33.0	29.0	133	58	12.7	19.5	0.58	
ER70-19	2	24.3			7.6		90.9								11.7
ER70-19	8	23.5			7.9		87.8	31.8	26.9	195	58	13.4	19.5	0.62	
ER70-20	0	23.5	1.3			8.36									
ER70-20	2	23.5			7.9		80.1	29.0	16.3	158	45	13.5	12.9	1.14	2.48
ER70-20	5	23.1			7.8		80.4	30.0	18.0	158	48	11.2	13.3	1.12	

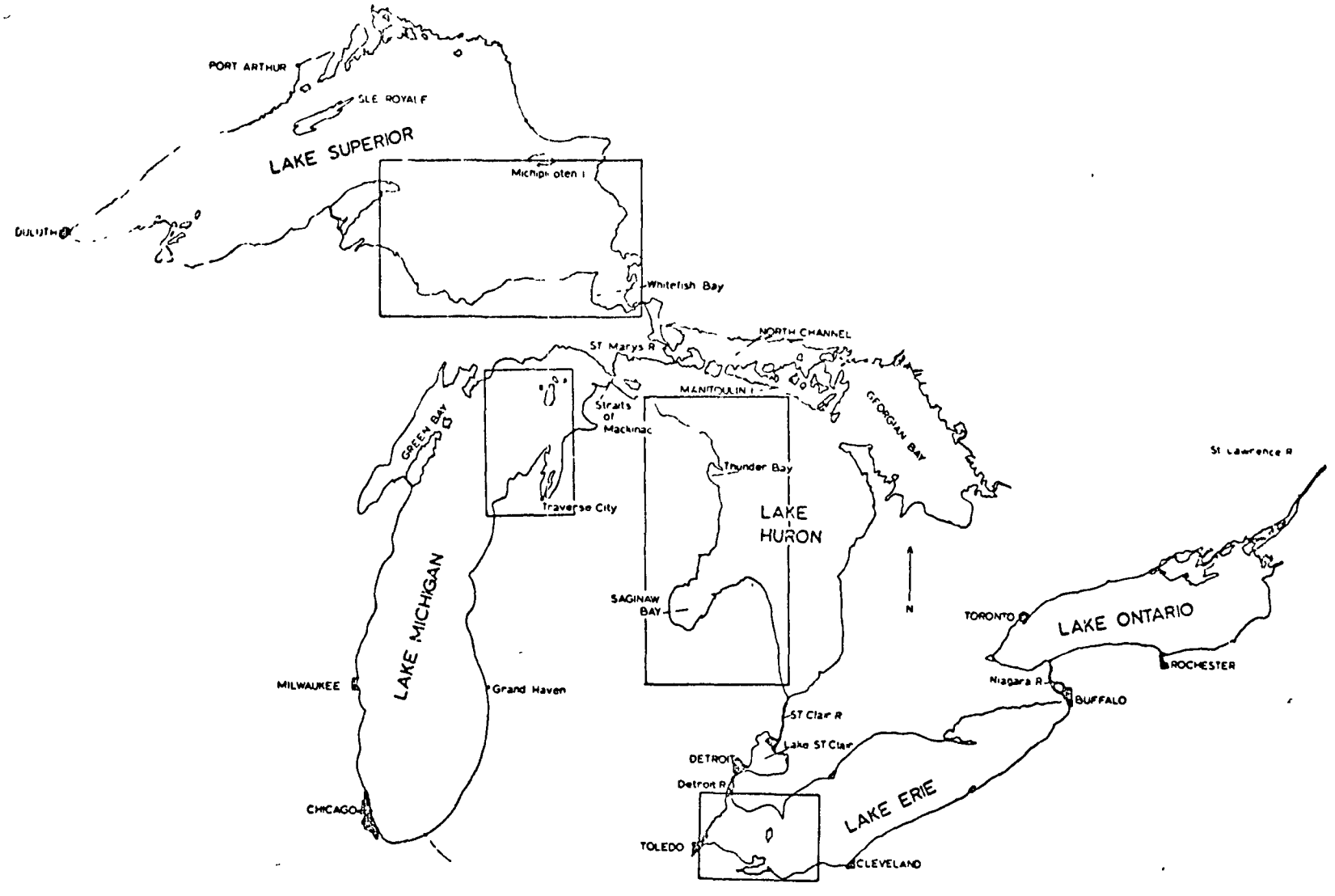

FIGURE 2. Map of St. Lawrence Great Lakes depicting areas studied in Lake Superior, Lake Michigan, Lake Huron and Lake Erie.

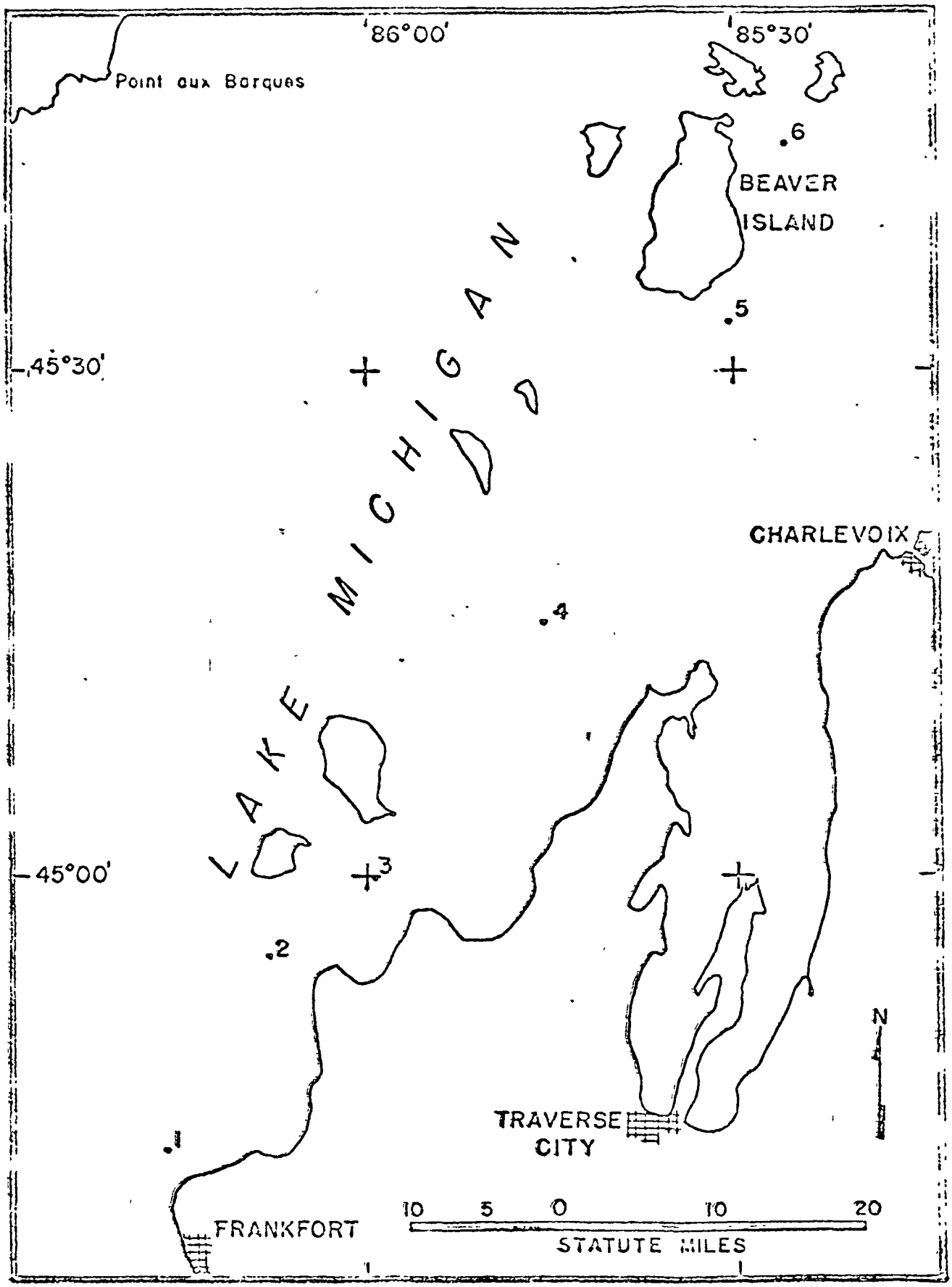

FIGURE 5. Lake Michigan sampling area showing locations of six stations.

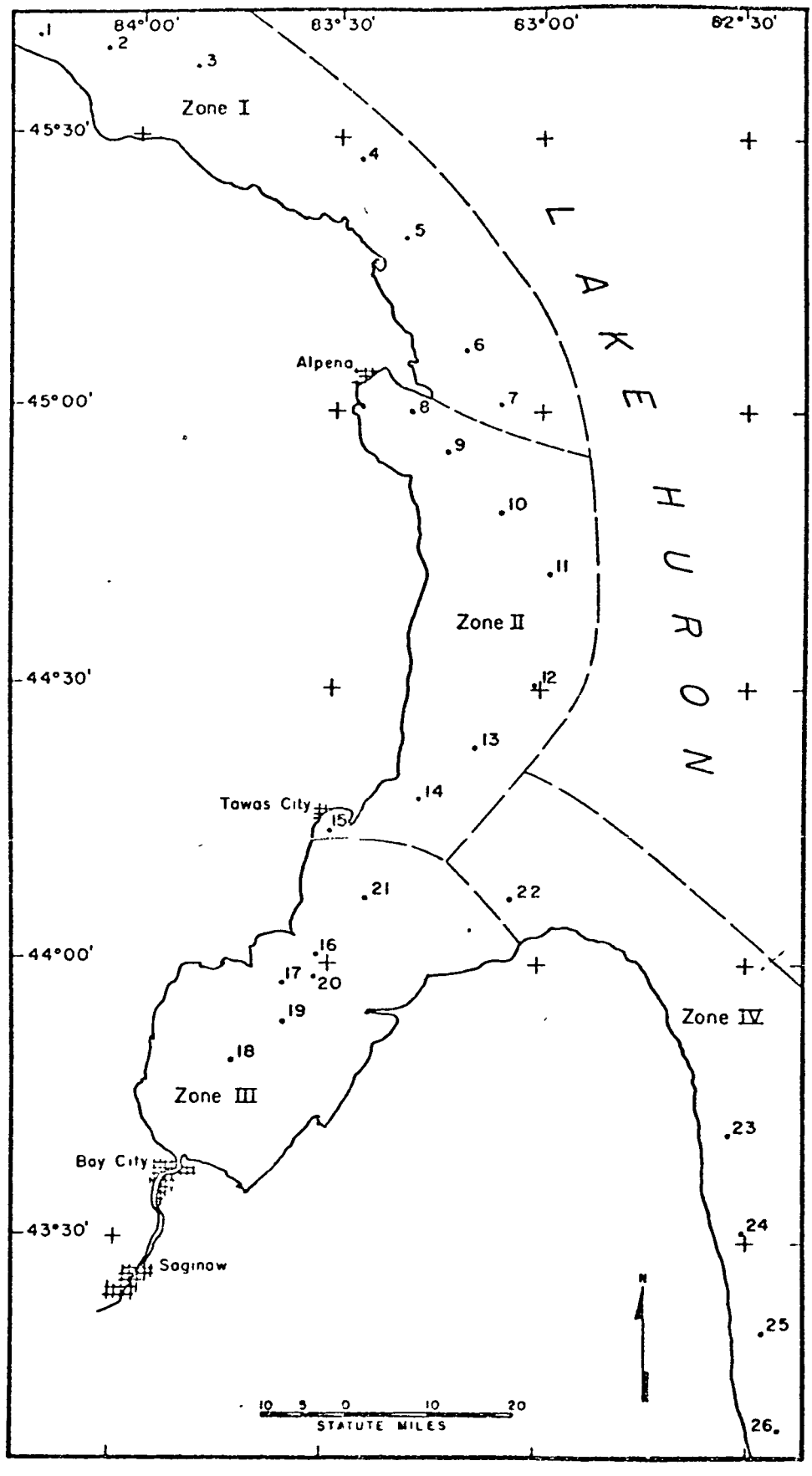

FIGURE 11. Lake Huron sampling area showing locations of 4 zones and 26 stations.

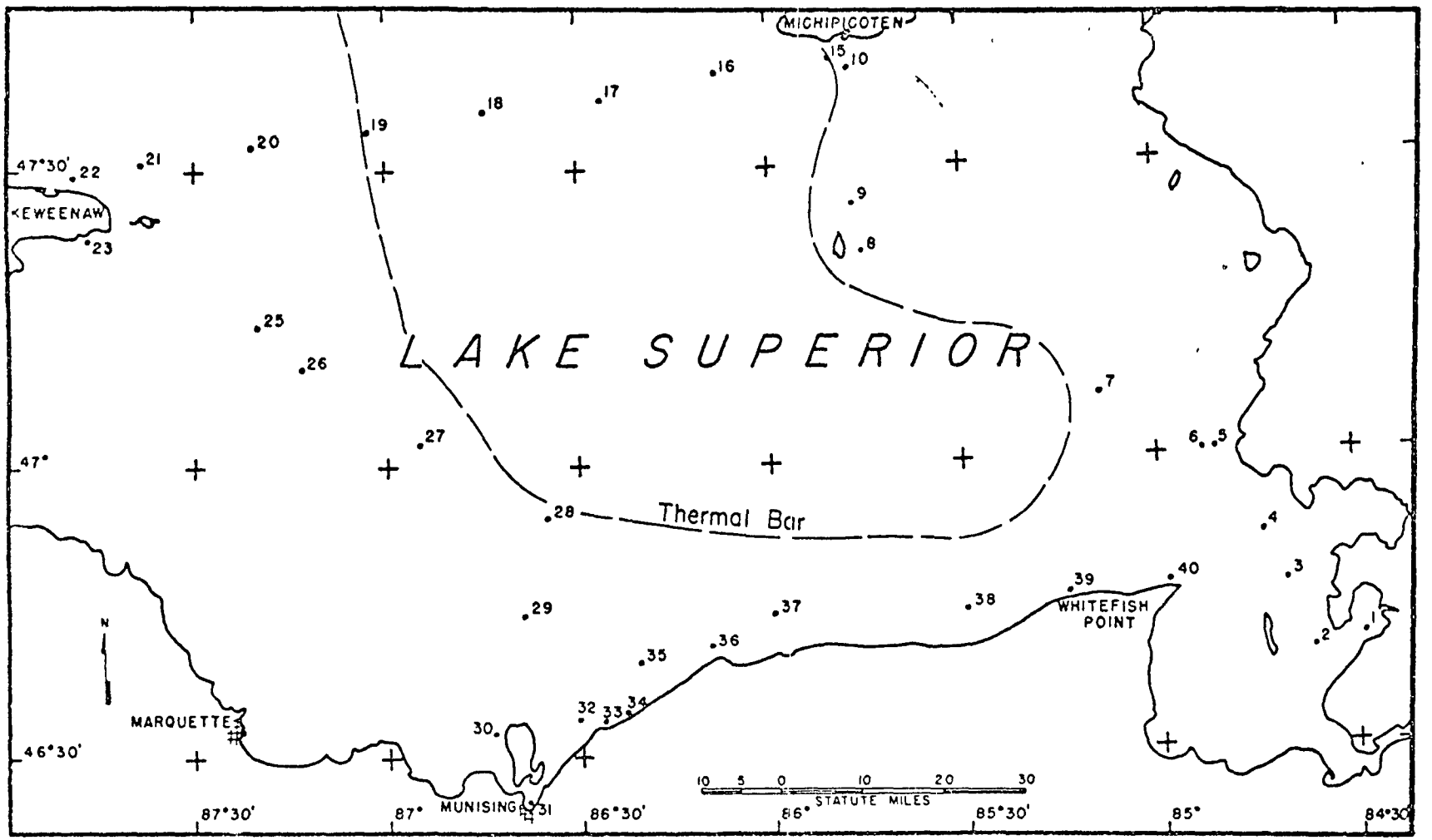

FIGURE 7. Lake Superior sampling area showing locations of 35 stations. Approximate limits of the thermal bar are indicated by the broken line.

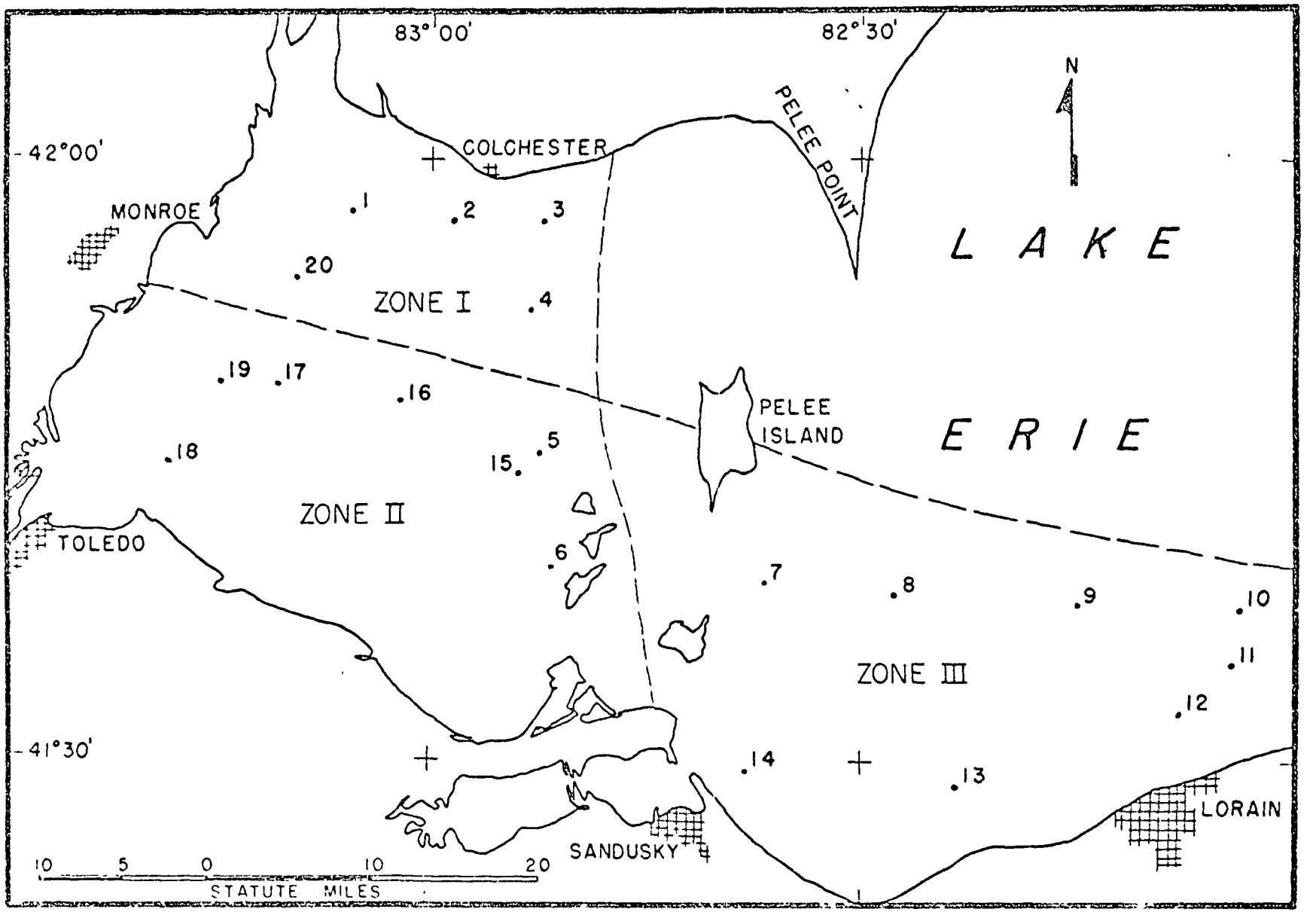

FIGURE 13. Lake Erie sampling area showing locations of 3 zones and 20 stations.

B 1

APPENDIX ~~2.1~~

SUMMARY OF LOWER LAKES DATA

LAKE ERIE

			Millions	
Basin population:	1966	USA	10.4	10.4
		CAN	1.4	1.4
	1986 (est.)	USA	15.4	15.4
		CAN	2.0	2.0

Lake Characteristics	English Units	Metric Units
Elevation, mean 1940-59	570.6 ft	173.9 m
Area: lake surface	9,970 mi^2	25,821 km^2
land drainage	29,650 mi^2	76,790 km^2
Volume	110 mi^3	458 km^3
Depth: maximum	210 ft	64 m
mean	58 ft	17.7 m
Outflow, mean annual	194,000 cfs	5,490 m^3/sec
Replenishment time	2.6 yr	2.6 yr
90% removal time (conservative pollutant)	6-7 yr	6-7 yr
Loading, total-P, 1967:		
entire lake	30,000 short tons/yr	27,300 metric tons/yr
per unit lake surface area	9.4 lb/acre.yr	1.6 g/m^2.yr
% retention in lake	84	84
% municipal and industrial	70	70
Loading, total-N, 1967:		
entire lake	194,000 short tons/yr	176,000 metric tons/yr
per unit lake surface area	61 lb/acre.yr	6.8 g/m^2.yr
% retention in lake	56	56
% municipal and industrial	30-40	30-40

LAKE ERIE BASINS

Lake Characteristics	W. Basin	C. Basin	E. Basin
Total dissolved solids, mg/l, mean	170	185	190
Specific conductance, µmhos/cm, 25°C, mean	280	310	320
Alkalinity, mg $CaCO_3$/l, mean	100	100	100
Turbidity, JTU	10-5	2	2
Total-N, µg N/l, mean	740	470	470
Total-P, µg P/l, mean	50	30	20
Deepwater sediments:			
% organic-carbon, lake range	0.2	0.2-3.6	
Eh (0-5 cm) volts, range		Entire lake range .288 - .147	

APPENDIX ~~2.2~~ B2

LAKE ONTARIO

			Millions	
Basin population:	1966	USA	2.3	2.3
		CAN	3.8	3.8
	1986 (est.)	USA	2.8	2.8
		CAN	4.8	4.8

Lake characteristics	English units	Metric units
Elevation, mean 1940-59	245.2 ft	74.7 m
Area: lake surface	7,340 mi^2	19,009 km^2
land drainage	24,800 mi^2	64,229 km^2
Volume	393 mi^3	1,638 km^3
Depth: maximum	802 ft	244 m
mean	276 ft	84 m
Outflow, mean annual	232,000 cfs	6,565 m^3/sec
Replenishment time	7.9 yr	7.9 yr
90% removal time (conservative pollutant)	21-22 yr	21-22 yr
Loading, total-P, 1967:		
entire lake	14,000 short tons/yr	12,700 metric tons/yr
per unit lake surface area	6.0 lb/acre.yr	0.65 g/m^2.yr
% retention in lake	78	78
% municipal and industrial	56	56
Loading, total-N, 1967:		
entire lake	173,000 short tons/yr	157,000 metric tons/yr
per unit lake surface area	73 lb/acre.yr	8.3 g/m^2.yr
% retention in lake	35	35
% municipal and industrial	30	30

LAKE ERIE BASINS

Lake Characteristics	W. Basin	C. Basin	E. Basin
Total dissolved solids, mg/l, mean	170	185	190
Specific conductance, µmhos/cm, 25°C, mean	280	310	320
Alkalinity, mg $CaCO_3$/l, mean	100	100	100
Turbidity, JTU	10-5	2	2
Total-N, µg N/l, mean	740	470	470
Total-P, µg P/l, mean	50	30	20
Deepwater sediments:			
% organic-carbon, lake range	0.2	0.2-3.6	
Eh (0-5 cm) volts, range		Entire lake range .288 - .147	

APPENDIX C1

SUMMARY OF WATER QUALITY DATA FOR LAKE ERIE (in mg/ℓ unit except where indicated)

CONSTITUENT	Buffalo, New York[a] Oct. 1958-Sept. 1959			Buffalo, New York[b] Oct. 1962-Sept. 1963			Buffalo, New York[c]	Lake Erie-Open Water[d]			Environmental and Biota Changes[e]	
	Low	Mean	High	Low	Mean	High	Mean	Min	Mean	Max	1900	1965
PHYSICAL CHARACTERISTICS												
Chlorine Demand (1 hr)	0.	0.8	1.8	0.1	0.8	2.6						
Chlorine Demand (24 hr)	0.2	2.3	3.7	1.1	1.9	4.0						
Color (units)	0.	0.1	10.	0.	0.	0.	0.					
Solids, Dissolved	121.	186.	264.	156.	201.	254.	204.				145.	200.
Specific Conductance (micro mhos @ 25°C)							306.	-	325.	-		
Temperature (indicate °F or °C)	1.5°C	15.9°C	25.8°C	0.0°C	12.2°C	26.0°C	75.0°F					
Turbidity (units-Jackson)	1.	3.	12.	0.0	12.	40.	12.					
BIOLOGICAL CHARACTERISTICS												
Algae, Total #/mℓ	30.	350.	850.	0.	233.	600.						
Coliform #/100mℓ	1.	18.	180.	4.	34.	230.						
CHEMICAL CHARACTERISTICS (INORGANIC)												
Alkalinity, Total (as $CaCO_3$)	49.	86.	98.	72.	86.	92.	95.	82.	115.	160.		
Ammonia (as N)	0.0	0.04	0.3	0.0	0.004	2.0						
Calcium							38.	30.	40.	71.	32.	38.
Chlorides	18.	27.	45.	18.	23.	25.	22.	7.	30.	130.	7.	24.
Hardness, Noncarbonate (as $CaCO_3$)							40.					
Hardness, Total (as $CaCO_3$)	110.	123.	136.	120.	134.	142.	127.					
Iron							0.03	0.01	0.04	0.12		
Magnesium							8.6	5.	9.	13.		
Nitrate							0.2	0.1	2.	10.		
Oxygen, Dissolved	8.0	11.7	15.	7.8	11.3	14.0						
pH (units)	7.4	8.1	8.5	7.9	8.2	8.6	8.1	6.28	8.0	8.77		
Phosphate (PO_4)				0.0	0.1	0.4	0.8					
Potassium							1.4	1.	5.	10.		
Silica							2.	0.2	2.	6.9		
Sodium							9.5	3.	10.	16.	6.	12.
Sulfates	17.	23.	27.	19.	24.	28.	23.	14.	35.	71.	13.	25.
(ORGANIC)												
BOD	0.1	0.8	2.3	0.7	1.7	3.9						
Carbon Alcohol Extract	0.107	0.140	0.206	0.098	0.118	0.173						
Carbon Chloroform Extract	0.025	0.049	0.064	0.028	0.049	0.066						
COD	0.3	6.	27.	4.	15.	141.						
(RADIOACTIVE)												
Total Alpha (pc/ℓ)	0.0	0.5	2.	0.0	0.3	2.						
Total Beta (pc/ℓ)	0.0	26.	69.	9.	25.	53.						

APPENDIX C_2

SUMMARY OF WATER QUALITY DATA FOR SOUTHERN LAKE MICHIGAN (in mg/ℓ units except where indicated)

CONSTITUENT	Gary, Indiana[a] Oct. 1958-Sept. 1959			Gary, Indiana[b] Oct. 1962-Sept. 1963			Gary, Indiana[c]	Mouth of Indiana Harbor Ship Canal[d] Nov.-Dec. 1967			Environmental and Biota Changes[e]	
	Low	Mean	High	Low	Mean	High	Mean	Min	Mean	Max	1900	1965
PHYSICAL CHARACTERISTICS												
Chlorine Demand (1 hr)	0.4	1.0	2.6	0.4	1.2	3.2						
Chlorine Demand (24 hr)	0.0	2.7	5.6	2.2	3.0	4.9						
Color (units)	5.	10.	25.	0.	8.	30.						
Solids, Dissolved	151.	169.	197.	144.	153.	186.		111.	181.	278	132.	154.
Solids Suspended								3.	10.	28.		
Temperature °C	1.4	11.9	21.1	1.4	10.3	21.6						
Turbidity (units)	1.	5.	18.	7.	12.	40.	16.					
BIOLOGICAL CHARACTERISTICS												
Algae, Total #/mℓ	450.	2340.	9740.	300.	1436.	3400.						
Coliform #/100 mℓ	4.	354.	2400.	1.	576.	7000.						
CHEMICAL CHARACTERISTICS (INORGANIC)												
Alkalinity, Total	102.	114.	130.	110.	119.	138.	122.					
Ammonia (as N)				0.0	0.2	0.4		0.01	0.49	1.8		
Calcium											34.	34.
Chlorides	6.	6.4	8.	4.	6.6	9.					3.9	7.5
Hardness, Total	130.	135.	147.	125.	132.	160.	142.					
Oxygen, Dissolved	6.7	11.	15.6	7.	10.6	14.9						
pH (units)	7.6	8.1	8.4	7.8	7.6	8.3	8.1	7.	8.	8.7		
Phosphate (PO_4)				0.	0.01	0.3		0.011	0.037	0.102		
Sulfates				21.	29.	45.					9.	18.
(ORGANIC)												
BOD	0.2	2.1	7.	0.1	0.8	3.						
Carbon Alcohol Extract	0.034	0.096	0.14	0.067	0.089	0.1						
Carbon Chloroform Extract	0.029	0.043	0.063	0.017	0.036	0.071						
COD	0.3	7.	26.	12.	28.	57.		1.3	11.6	50.		
(RADIOACTIVE)												
Total Alpha (pc/ℓ)	0.	0.4	2.	0.	0.5	4.						
Total Beta (pc/ℓ)	1.	25.	109.	3.	14.	30.						

APPENDIX C_3

SUMMARY OF WATER QUALITY DATA FOR LAKE SUPERIOR (in mg/ℓ units except where indicated)

CONSTITUENT	Duluth, Minnesota[a] Oct. 1958-Sept. 1959			Duluth, Minnesota[b] Oct. 1962-Sept. 1963			Environmental and Biota Changes[e]	
	Low	Mean	High	Low	Mean	High	1900	1965
PHYSICAL CHARACTERISTICS								
Chlorine Demand (1 hr)	0.7	1.0	1.8	0.5	0.7	1.		
Chlorine Demand (24 hr)	1.3	2.4	3.4	1.1	1.4	2.2		
Color (units)	0.	2.3	15.	0.	0.8	5.		
Solids, Dissolved	35.	54.	76.	49.	56.	64.	59.	55.
Temperature °C	0.6	5.5	17.2	1.1	5.8	20.		
Turbidity	0.	0.7	6.	0.	1.	25.		
BIOLOGICAL CHARACTERISTICS								
Algae, Total #/mℓ	50.	240.	780.	0.	118.	500.		
Coliform #/100 mℓ	1.	12.	68.	1.	54.	830.		
CHEMICAL CHARACTERISTICS (INORGANIC)								
Alkalinity, Total (as $CaCO_3$)	39.	43.	45.	42.	43.	44.		
Ammonia	0.1	0.06	0.3	0.	0.	0.		
Calcium							13.	12.
Chlorides	1.	1.8	2.	2.	2.	2.	2.	2.
Hardness, Total (as $CaCO_3$)	37.	41.	45.	42.	44.	45.		
Oxygen, Dissolved	9.4	12.5	14.	9.8	12.3	14.		
pH (units)	7.5	7.7	8.	7.4	7.5	7.8		
Phosphate (PO_4)				0.	0.	0.		
Sodium							3.	2.
Sulfates	1.	3.7	5.	2.	2.5	4.	4.	3.
(ORGANIC)								
BOD	0.3	0.5	1.	0.2	0.4	1.		
Carbon Alcohol Extract	0.063	0.094	0.116	0.033	0.067	0.081		
Carbon Chloroform Extract	0.021	0.026	0.034	0.014	0.022	0.033		
COD	2.	4.3	8.8	5.	8.6	12.		
(RADIOACTIVE)								
Total Alpha (pc/ℓ)	0.	0.09	1.	0.	0.	0.		
Total Beta (pc/ℓ)	0.	18.	148.	3.	17.	28.		

APPENDIX C_3

SUMMARY OF WATER QUALITY DATA FOR LAKE SUPERIOR (in mg/ℓ units except where indicated)

CONSTITUENT	Duluth, Minnesota[a] Oct. 1958-Sept. 1959			Duluth, Minnesota[b] Oct. 1962-Sept. 1963			Environmental and Biota Changes[e]	
	Low	Mean	High	Low	Mean	High	1900	1965
PHYSICAL CHARACTERISTICS								
Chlorine Demand (1 hr)	0.7	1.0	1.8	0.5	0.7	1.		
Chlorine Demand (24 hr)	1.3	2.4	3.4	1.1	1.4	2.2		
Color (units)	0.	2.3	15.	0.	0.8	5.		
Solids, Dissolved	35.	54.	76.	49.	56.	64.	59.	55.
Temperature °C	0.6	5.5	17.2	1.1	5.8	20.		
Turbidity	0.	0.7	6.	0.	1.	25.		
BIOLOGICAL CHARACTERISTICS								
Algae, Total #/mℓ	50.	240.	780.	0.	118.	500.		
Coliform #/100 mℓ	1.	12.	68.	1.	54.	830.		
CHEMICAL CHARACTERISTICS								
(INORGANIC)								
Alkalinity, Total (as $CaCO_3$)	39.	43.	45.	42.	43.	44.		
Ammonia	0.1	0.06	0.3	0.	0.	0.		
Calcium							13.	12.
Chlorides	1.	1.8	2.	2.	2.	2.	2.	2.
Hardness, Total (as $CaCO_3$)	37.	41.	45.	42.	44.	45.		
Oxygen, Dissolved	9.4	12.5	14.	9.8	12.3	14.		
pH (units)	7.5	7.7	8.	7.4	7.5	7.8		
Phosphate (PO_4)				0.	0.	0.		
Sodium							3.	2.
Sulfates	1.	3.7	5.	2.	2.5	4.	4.	3.
(ORGANIC)								
BOD	0.3	0.5	1.	0.2	0.4	1.		
Carbon Alcohol Extract	0.063	0.094	0.116	0.033	0.067	0.081		
Carbon Chloroform Extract	0.021	0.026	0.034	0.014	0.022	0.033		
COD	2.	4.3	8.8	5.	8.6	12.		
(RADIOACTIVE)								
Total Alpha (pc/ℓ)	0.	0.09	1.	0.	0.	0.		
Total Beta (pc/ℓ)	0.	18.	148.	3.	17.	28.		

APPENDIX C_3

SUMMARY OF WATER QUALITY DATA FOR LAKE SUPERIOR (in mg/ℓ units except where indicated)

CONSTITUENT	Duluth, Minnesota[a] Oct. 1958-Sept. 1959			Duluth, Minnesota[b] Oct. 1962-Sept. 1963			Environmental and Biota Changes[e]	
	Low	Mean	High	Low	Mean	High	1900	1965
PHYSICAL CHARACTERISTICS								
Chlorine Demand (1 hr)	0.7	1.0	1.8	0.5	0.7	1.		
Chlorine Demand (24 hr)	1.3	2.4	3.4	1.1	1.4	2.2		
Color (units)	0.	2.3	15.	0.	0.8	5.		
Solids, Dissolved	35.	54.	76.	49.	56.	64.	59.	55.
Temperature °C	0.6	5.5	17.2	1.1	5.8	20.		
Turbidity	0.	0.7	6.	0.	1.	25.		
BIOLOGICAL CHARACTERISTICS								
Algae, Total #/mℓ	50.	240.	780.	0.	118.	500.		
Coliform #/100 mℓ	1.	12.	68.	1.	54.	830.		
CHEMICAL CHARACTERISTICS (INORGANIC)								
Alkalinity, Total (as $CaCO_3$)	39.	43.	45.	42.	43.	44.		
Ammonia	0.1	0.06	0.3	0.	0.	0.		
Calcium							13.	12.
Chlorides	1.	1.8	2.	2.	2.	2.	2.	2.
Hardness, Total (as $CaCO_3$)	37.	41.	45.	42.	44.	45.		
Oxygen, Dissolved	9.4	12.5	14.	9.8	12.3	14.		
pH (units)	7.5	7.7	8.	7.4	7.5	7.8		
Phosphate (PO_4)				0.	0.	0.		
Sodium							3.	2.
Sulfates	1.	3.7	5.	2.	2.5	4.	4.	3.
(ORGANIC)								
BOD	0.3	0.5	1.	0.2	0.4	1.		
Carbon Alcohol Extract	0.063	0.094	0.116	0.033	0.067	0.081		
Carbon Chloroform Extract	0.021	0.026	0.034	0.014	0.022	0.033		
COD	2.	4.3	8.8	5.	8.6	12.		
(RADIOACTIVE)								
Total Alpha (pc/ℓ)	0.	0.09	1.	0.	0.	0.		
Total Beta (pc/ℓ)	0.	18.	148.	3.	17.	28.		

APPENDIX D

(OPEN WATER AVAILABLE FROM STORET.)

APPENDIX E

(GREAT LAKES INSHORE DATA AVAILABLE FROM US EPA-RV STORET, see also, Reference 1 & 2)

ENVIRONMENTAL PROTECTION AGENCY
REGION V

(EVAL 19)

APPENDIX F

REPLY TO ATTN OF: Walter W. Kovalick, Jr., Administrative Assistant, ORA DATE: March 7, 1973

SUBJECT: LMEC Non-Thermal Issues - Follow-Up

TO: Director, Air and Water Programs Division
Director, Categorical Programs Division
Director, Enforcement Division
Director, Surveillance and Analysis Division
Director, Office of Research and Monitoring

The attached table reflects my notes of the January 30 meeting of the various programs. I am scheduling another meeting of the working group on Thursday, March 15 at 9:00 A.M. in the Regional Administrator's Conference Room.

Walter W. Kovalick, Jr.

Walter W. Kovalick, Jr.

Attachment

EPA Form 1320-6 (11-71)

January 30, 1973

TOPIC	DESCRIPTION OF RECOMMENDATION	ACTION TO DATE	FURTHER ACTION
Interim Phosphorus Removal (12/72)	States use interim facilities	Enforcement ltr. 1/8/73 Responses from Wis. and Mich.	Forward copies to central file. (Ind. ltr. recd. 2/25/73)
Industrial Waste Control	List of sources	BPI list reviewed by SAD with some additions	Copies of list to programs by SAD.
	Future permits		Enf. permits will reflect consideration of list (24 permits est. by 3/18)
Combined Sewers	States prepare list	Covered in ENF. ltr. 1/10/73	State action
Non-Public Waste Dischargers	States evaluate	Covered in ENF. ltr. 1/10/73	State action
Chlorides	Limit with permits		Will limit with EPA-State permits
	Detailed studies	SAD has met with OGLC - no info. at 1/30/73 session	SAD responsibility
Phosphorus-Removal	States evaluate needs & costs	2 State ltrs. recd.	ENF. solicits others
	EPA evaluates info.		ENF. will evaluate
	Promote soil conservation	No work assignment in SAD reported 1/30/73	?
	Promote eutro. research	ORM developed research need	ORM to follow algal assay requested by ENF.
Pesticides	Liaison with BSFW	None	SAD will follow-up.
	States advocate legislation to record HC usage	No longer relevant per CPD until OEGC opinion rendered	CPD will send model legislation to States & internal Reg. V programs.

OPIC	DESCRIPTION OF RECOMMENDATION	ACTION TO DATE	FURTHER ACTION
CB's	States survey and report	Mich. responded	ENF. will follow-up
	States report elimination		
	States monitor		
hthalates	Inauguration of phthalate trends survey	SAD 12/26/72 ltr. & State meetings held	SAD follow-up
	Accelerate R&D on toxicity for aquatic organisms	ORM asked HQ & NWQL to accelerate interest	ORM follow-up
	FDA requested to eval. problem	None	ORM will receive ltr. and attachments
race Metals	Higher priority for R&D	Programs didn't support research NEEDS (see below)	ORM will contact NWQL - Mount
	States monitor trace metals	SAD 12/26/72 letter & State meetings held	SAD follow-up
	States decrease trace metals		Permits by States-EPA
	New research NEEDS	3 ORM research NEEDS rejected by programs	ORM & A&W will rewrite need statement

TOPIC	DESCRIPTION OF RECOMMENDATION	ACTION TO DATE	FURTHER ACTION
Taste and Odor	Green Bay area investigations	ENF. sent 1/9/73 ltr. to Wis. to take lead	ENF. follow-up
	Research on removal	Research NEEDS in system Mich. has submitted study proposal	
Toxic Substances	Membership on Committee		Mayo appointed Pearson, Conlon, and Hanok

APPENDIX G (EVAL 20)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUBJECT Great Lakes Initiative Contract Program

DATE: March 5, 1973

FROM: James O. McDonald, Director
Enforcement Division

TO. Dr. Robert W. Zeller, Director
Surveillance & Analysis Division

Please be advised that a Request for Proposal (RFP) for Investigations on the Great Lakes will soon be issued to contractors responding to our October 27, 1972 advertisement in the Commerce Business Daily (attached). A copy of the RFP will be sent to you upon issuance.

Preproposal meetings have been scheduled in order to provide prospective contractors with the opportunity to question the U.S. Environmental Protection Agency (EPA) and State agencies with regard to relevant information needs and sources as well as the intents and purposes of the RFP. We would appreciate it if one of your staff could attend the meetings indicated below and contribute to the discussions.

Preproposal meeting for Upper Lakes Special Attention Areas

AREAS:
- Duluth - Superior
- Fox River - Green Bay
- Calumet Area
- Saginaw Bay and River

Region V, EPA, 1 North Wacker Drive, Chicago, Illinois, on March 22, 1973, at 10:00 A.M., in Conference Rooms 10 A and B.

Preproposal meeting for Region V Lake Erie Special Attention Areas

AREAS:
- Detroit Area
- Maumee River - Toledo
- Cleveland Area
- Ashtabula River

Region V, EPA, 1 North Wacker Drive, Chicago, Illinois, on March 22, 1973, at 2:00 P.M., in Conference Rooms 10 A and B.

EPA Form 1320-6 (Rev. 6-72)

In mid or late April, proposals on the above areas will be due. We are soliciting service by your staff on proposal review panels for these areas and subsequent participation on these panels in evaluation of progress reports, etc. A draft "scope of services statement" similar to the one that will be in the RFP is enclosed for your information.

Questions or comments should be referred to Mr. Howard Zar at 353/1470.

Please advise Mr. Zar by March 15, 1973 whether one of your staff can attend.

James O. McDonald, Director
Enforcement Division

SCOPE OF SERVICES STATEMENT

Great Lakes Initiative Contract Program

Project Title - Water Quality Investigation of 12 Great Lakes "Special Attention" Areas

Estimated period of Performance - One year

Project Officer -

Background - The USEPA has identified twelve areas in the Great Lakes Region having the worst water pollution problems as well as the municipal and industrial concentration. The twelve "Special Attention" Areas and their areas of primary geographic focus are as follows: (See Attachment). The newly adopted Federal Water Pollution Control Act Amendments of 1972 present a variety of information requirements in these areas. Contractors are desired for each of the twelve areas.

Purpose - The USEPA desires to obtain additional data regarding the present nature and trends in water quality, aquatic life, and waste loadings in each of the areas. The Agency also desires to obtain additional information regarding the expected improvement in water quality upon application of effluent guidelines developed in accordance with the new act. The work is directed towards meeting the Agency's commitment under the Great Lakes Water Quality Agreement of April 15, 1972 between the U.S. and Canada for accelerated effort to abate and control water pollution in the Great Lakes. The data thus obtained will be used to accelerate development of NPDES waste discharge permits in accordance with

provisions of the 1972 Amendments to the Federal Water Pollution Control Act Amendments of 1972 and in the assessment of compliance with water quality standards and NPDES permits.

Procurement

Abstract - The contractor shall supply the necessary personnel, materials, facilities, and services to perform comprehensive water quality investigations for one or more of the twelve "Special Attention" Area

Scope of Work -

Task I - Historical Data Analysis

A. Accumulation and evaluation of the existing data base & historical trends within the "Special Attention" area for the following:

1. Community structure of aquatic plant & animal populations.
2. Nature and variation of water quality for a standard array of physical, chemical, and microbiological parameters. The array of parameters shall be based on those used in the NPDES permit system.
3. Particular attention should be given to the areas near major discharges and to the impact of those discharges on aquatic life & water quality. Specific evaluation of water quality criteria violations should be made.

B. Significant Gaps and underemphasis in the current data basis should be identified. Recommendations for further field studies should be made.

C. In developing historical data the contractor shall consult available reports and data. Special attention should be given to data gathering efforts by others occurring concurrently with this contract. Requests for assistance from State & Federal Pollution Control agencies should be minimized through

extensive use of publicly available reports, hearing records etc. Canvassing shall include but not be limited to the

1. Proceedings of the Conference on Great Lakes Research and other published scientific and technical literature.
2. Enforcement Conference Proceedings
3. Impact Statements
4. Enviro-Control Inc. contract report for EPA
5. NOAA sea grant program results
6. Federal & State Pollution Control Agencies including data in NPDES permit applications and the Storet system.

Task II - Field Sampling

A. With the objectives of part A of Task I, field investigations shall be conducted at a sufficient level of effort to produce together with Task I a comprehensive & current picture of aquatic biology, water quality, areas of water quality standards violations, and impact of major discharges. A substantial field program is contemplated. The emphasis of the field studies should be the closing of gaps and deficiencies in the existing data base and verification of existing data. Duplication of data obtained by other efforts should be minimized.

B. Field efforts shall be tailored to the specific needs of this contract. Reasonable efforts should be made to make this work complementary to concurrent field studies performed by pollution control agencies or for them under contract, especially those efforts undertaken for the purpose of implementing the FWPCA Amendments of 1972 or the Great Lakes Initiative program.

Task III - Effluent Analysis

A. Preparation of a profile of present discharges covered by the NPDES program within or significantly affecting the "Special Attention" area for a standard array of parameters. The array of parameters shall be based on those used in the NPDES permit system. Sufficient information should be obtained to draw a comprehensive picture of such loadings and together with Task I and II to evaluate the present impact of major discharges.

B. Comparison of present discharge profiles with the "best practicable" and "best available" profiles established in accordance with provisions of the 1972 Amendments to the Federal Water Pollution Control Act.

C. In developing this data the contractor shall rely primarily on data within the NPDES system and published reports.

Task IV - Data Analysis & projection

A. To statistically analyze and interrelate the data obtained in Tasks I, II & III to establish levels and trends in the various parameters; to determine the relationship between the discharges, water quality & aquatic life; to determine the areas where water quality standards are now being violated; and to create a computer-based bank for this data which is compatible with information systems in use by EPA and State agencies.

B. To make projections on the basis of the data compiled by this contract and effluent guidelines established in accordance with the FWPCA Amendments of 1972 that can be achieved within the time and cost restraints of this contract.

Water Quality Modeling efforts, if needed, should be of a straightforward nature; utilizing straightforward waste allocation techniques, existing models, and models now under development by other efforts to implement the Federal Water Pollution Control Act Amendments of 1972.

1. The levels of water quality that would result if effluent guidelines established by the administrator for compliance with sections 301(b)(1)(A) and 301(b)(1)(B) of the 1972 amendments were met.
2. The levels of water quality that would result if effluent guidelines established by the administrator for compliance with sections 301(b)(2)(A) and 301(b)(2)(B) of the 1972 amendments were met.
3. The effluent levels (if tighter than those referred to above) which are necessary to meet water quality standard and/or the requirements of the 1972 act for "the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the water".

C. To make a final report which presents a comprehensive picture of water quality in the "special attention area", incorporating the foregoing objectives.

D. To conduct a seminar at the EPA Regional Office in Chicago and one other at a place to be designated in order to advise selected Federal, State, and local agency personnel regarding the significance and use of this information.

Type reports & frequency of delivery -

A. Monthly progress report (standard requirements)

B. Detailed draft report for Tasks I (within 3 months)

C. Study plan for Tasks II (within 3 months)

D. Study plan for Tasks IV (within 5 months)

E. Final report (within 14 months).

F. Seminars (within 16 months)

Evaluation Criteria -

A. Comprehensiveness & Applicability of Work Plans & Consideration of Special Technical Problems.

B. Demonstrated capability for the performance of complex water quality, biological. & effluent studies for the purpose of determining & projecting pollutional impact.

1. Experience & knowledge of aquatic biology, water quality, industrial wastes, & municipal wastes.

2. Knowledge of the "special attention area".

3. Project personnel qualifications & utilization

4. Adequacy of field, laboratory, & computer facilities

C. Ability of contractor's staff to participate in administrative or judicial proceedings with respect to information gathered during the course of this study.

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(P299)

A--INVESTIGATIONS ON THE GREAT LAKES. The aim of these investigations is to assess compliance with water quality standards and waste discharge permits for twelve "Special Attention Areas," Duluth-Superior, Fox River of Wisconsin and Green Bay, Calumet area of Lake Michigan, Saginaw Bay and River, Detroit area, Maumee River, Toledo area, Cleveland area, Ashtabula River, Erie, PA, Buffalo-Niagara, Lake Onondaga and the Black River (New York).— These comprehensive investigations of water pollution will encompass biological, chemical and physical field studies as well as historical data evaluations, with particular emphasis on the impact of major waste discharges. The data obtained from any resultant contract is intended for use in measuring the progress of the United States in implementing the articles of the "Great Lakes Agreement" to support litigation reports against specific enforcement targets and to support compliance reports for use in enforcement actions. Firms having the capability to perform in the above areas should submit a brief (not to exceed ten (10) page prospectus). The prospectus should detail the firms' capabilities, technical expertise and experience in the area of water pollution investigations. Resumes of available personnel that would be used for performing work in this area should also be included in the prospectus. This is not a Request for Proposals. Respondents will not be notified of the evaluation results and only those firms determined to be best qualified will receive a copy of any resultant RFP. An original and three copies of each qualifications proposal shall be delivered on or before 30 Nov 72 — Brochures are not acceptable and submission must include data pertinent to this requirement. (P299)

Environmental Protection Agency,
Special Projects Procurement Section,
Crystal Mall #2, Room 703,
Washington, DC 20460

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* A--DESIGN, FABRICATE AND PROVIDE SOFT MOUNTS, approx one hundred-two, consisting of shelf trays and a new mounting tray for the AN/ARR-75 Sonobuoy Receiver, update AFC-515 to incorporate the aforesaid soft mounts. The Naval Air Systems Command intends to negotiate with Martin-Marietta Corp., Eastern Ave.,

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73-A041. (P299)

Environmental
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PROGRESS REPORT February 22, 1973

TO: Great Lakes Water Quality Board

FROM: Land Drainage Reference Group

The Governments of Canada and the United States of America, pursuant to Article IX of the Boundary Waters Treaty of 1909, requested the International Joint Commission to conduct a study of pollution of the boundary waters of the Great Lakes System from agricultural, forestry and other land use activities, in the light of the provision of Article IV of the Treaty which provides that the boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health and property on the other side, and in the light also of the Great Lakes Water Quality Agreement signed on April 15, 1972.

The Commission was requested to enquire into the report to the two Governments upon the following questions:

(1) Are the boundary waters of the Great Lakes System being polluted by land drainage (including ground and surface runoff and sediments) from agriculture, forestry, urban and industrial land development, recreational and park land development, utility and transportation systems and natural sources?

(2) If the answer to the foregoing question is in the affirmative, to what extent, by what causes, and in what localities is the pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what remedial measures would, in its judgment, be most practicable and what would be the probable cost thereof?

The Commission was requested to consider the adequacy of existing programs and control measures, and the need for improvements thereto, relating to:

(a) inputs of nutrients, pest control products, sediments, and other pollutants from the sources referred to above;

(b) land use;

(c) land fills, land dumping, and deep well disposal practices;

(d) confined livestock feeding operations and other animal husbandry operations; and

(e) pollution from other agricultural, forestry and land use sources.

./2

GREAT LAKES INITIATIVE PROGRAM

"Special Attention" Areas

1.	Calumet Area -	Near shore area of Lake Michigan and contiguous harbors between Chicago south water intake and Burns Harbor.
2.	Duluth - Superior -	St. Louis River, Cloquet to the harbor; Duluth-Superior Harbor; near shore areas of Lake Superior adjacent to Duluth, Minnesota and Superior Wisconsin.
3.	Fox River and Green Bay-	Lower Fox River and Lower Green Bay (out to Sturgeon Bay).
4.	Saginaw Bay and River -	Saginaw Bay, Port Austin to Tawas; Saginaw River, City of Saginaw to the Mouth.
5.	Detroit Area -	St. Clair River, Lake St. Clair, Detroit River, Near shore area of Lake Erie south to Monroe Michigan.
6.	Maumee River and Toledo -	Ohio portion of the Maumee River and Maumee Bay.
7.	Cleveland Area -	Cuyahoga River to mile point 60, near shore area of Lake Erie from Rocky River to Euclid, Black River from Elyria to the mouth.
8.	Ashtabula River -	Ashtabula River, mile point 3.0 to the mouth; Fields Brook.
9.	Erie, Pa. Area -	To be defined at a later date.
10.	Buffalo - Niagara -	Niagara River, Lake Shore of the city of Buffalo.
11.	Black River -	Black River from Kayuta reservoir to the mouth Sackets Harbor of Lake Ontario.
12.	Rochester - Genesee -	Genesee River from Mount Morris to the mouth, near shore area of Lake Ontario between Hamilton.

REGION V

APPENDIX H

REPLY TO ATTN OF: Walter W. Kovalick, Jr., Administrative Assistant, ORA

DATE: February 20, 1973

SUBJECT: Critique of Enviro-Control Briefing - February 16, 1973

TO: Director, Air and Water Programs Division
Director, Enforcement Division
Director, Surveillance and Analysis Division
Director, Office of Research and Monitoring
Director, Office of State and Interstate Programs
Coordinator for Great Lakes

As Mr. Mayo indicated at the staff meeting we are to prepare an in-depth critique of the conclusions and commentary expressed in the briefing document presented by Mr. Sprey. Our critique shall be of only two of the States that he analyzed -- Indiana and Michigan.

Using the briefing document as a starting point, please comment on its tabular and prose discussions and conclusions, and reference pertinent data bases (including computerized), publications, reports, etc. In addition, a list of individuals contacted by Enviro-Control in each of our Great Lakes States will follow (when it is received).

Please attach to your critique a list, by State, of individuals that you feel were critical to the conclusions of the document, but not interviewed. You may be interested to know that there is no final report extant relating the 15,000 page data base to the briefing document. One will eventually be prepared.

Your comments and lists will be consolidated and submitted to headquarters as well as to the consultant. In addition, site visits to Indiana and Michigan may be scheduled to retrace the consultant's steps.

Your response is requested by COB March 9, 1973, so that our comments may be consolidated and forwarded by early the next week.

Walter W. Kovalick, Jr.

Walter W. Kovalick, Jr.

EPA Form 1320-6 (11-71)

EVAL (21)

Section 124.43 of the Federal Permit Regs state that BPT or alternative load allocations will have to meet WQS.

POLLUTION ABATEMENT IN THE GREAT LAKES BASIN: BRIEFING NOTES

Submitted to: Office of Planning and Evaluation
Environmental Protection Agency
Washington, D. C.

Submitted by: Enviro Control, Inc.
960 Thompson Avenue
Rockville, Maryland 20852

301-770-2100
Pierre Spirey

February, 1973

I. STUDY OBJECTIVES

The original objective of the current investigation was to determine, from the available evidence, the extent of progress in abating pollution in the Great Lakes Basin since the Water Pollution Control Act of 1965 -- and to understand the reasons for progress or lack of progress. It was hoped the study results would be directly applicable to implementing the new Act.

A number of hypotheses were to be tested based on the data collected; them included the following:

1. State political climate, legislative powers, formal administrative structure, manpower and budget are significant factors in achieving progress.
2. Most States are underfunded.
3. Some States, if not most, will enforce more vigorously against small dischargers than against large ones.
4. It is possible to structure a reporting scheme which, when implemented by the States, will allow EPA to evaluate their progress, based on submitted reports.
5. Federal efforts, at least since 1965, have had a significant effect on abatement progress.
6. States enjoying excellent reputations within EPA (viz. Michigan) have made significant progress; States with a reputation for weak programs have made little progress (viz. Indiana).

II. STUDY METHODS

The vast bulk of the study effort was expended in collecting a sizable sample of thoroughly documented municipal and industrial discharger case histories, intended to track quantitative changes in effluent loads (and local water quality) as well as the chronology of State and Federal actions with respect to each discharger. Emphasis was placed on collecting data on most of the largest dischargers plus a representative sample of smaller ones.

The data sources included Region V enforcement files, State files and individual discharger files. The study team microfilmed and cataloged 15,000 pages of primary source documents, in addition to collecting a small library of State and Federal reports, proceedings and hearings; this material is being submitted as the backup to the summaries of each discharger and State. Because the historical perspective became so interesting, individual discharger cases were traced back to the 1940's; archival material was used to trace State programs back to World War I in most cases.

The study team was given unrestricted access to the files of each Great Lakes State with the single exception of New York. New York reserved the right to censor each file requested and consequently was not evaluated. The process of collecting data from State and Federal files permitted team members to enjoy working

contact with an excellent cross section of personnel from in each State water quality program, ranging from program directors to field engineers. Each cooperating State was briefed informally on the approximate findings of the study in that State and was invited to comment.

The evidence collected in each State (as well as the final evaluation) focussed on answering the following simple questions:

1. Does the State know the quality of its waters, including changes in quality over time and violations of standards (i. e., does it monitor sensibly)?
2. Does the State know its pollution sources and what they are discharging?
3. Does the State know the effect of these discharges on water quality and does it write reasonable waste allocations, orders or permits based on this knowledge (i. e., does it plan competently)?
4. Does the State inspect, enforce and achieve compliance after writing these orders?
5. Does the State know whether water quality improved after compliance?
6. Has water quality improved in the State?

In answering these questions, quantitative evidence supported by measurements (on the rare occasions when it was available) was always preferred over qualitative judgments.

III SUMMARY EVIDENCE

A. Overview of Pollution in the Great Lakes

1. Great Lakes Map
2. Water Quality Measurements for Great Lakes
3. Reliable Evidence of Open Water WQ Changes
4. Phosphorus Budget

B. State Performance

1. Evaluation of States with respect to Basics
2. Pennsylvania, Notes & Effluent Table
3. Ohio, Notes & Effluent Table
4. Illinois, Notes & Effluent Table
5. Minnesota, Notes & Effluent Table
6. Indiana, Notes & Effluent Table
7. Michigan, Notes & Effluent Table
8. Wisconsin, Notes & Effluent Table
9. Lack of correlation - State Program Plan vs. Performa
10. Claimed Sewer and Treatment Level, 1940 -- 1962
11. An Historical View

C. Federal Performance and Construction Grants

1. Notes on the Federal Program
2. Construction Effort and Grants by State

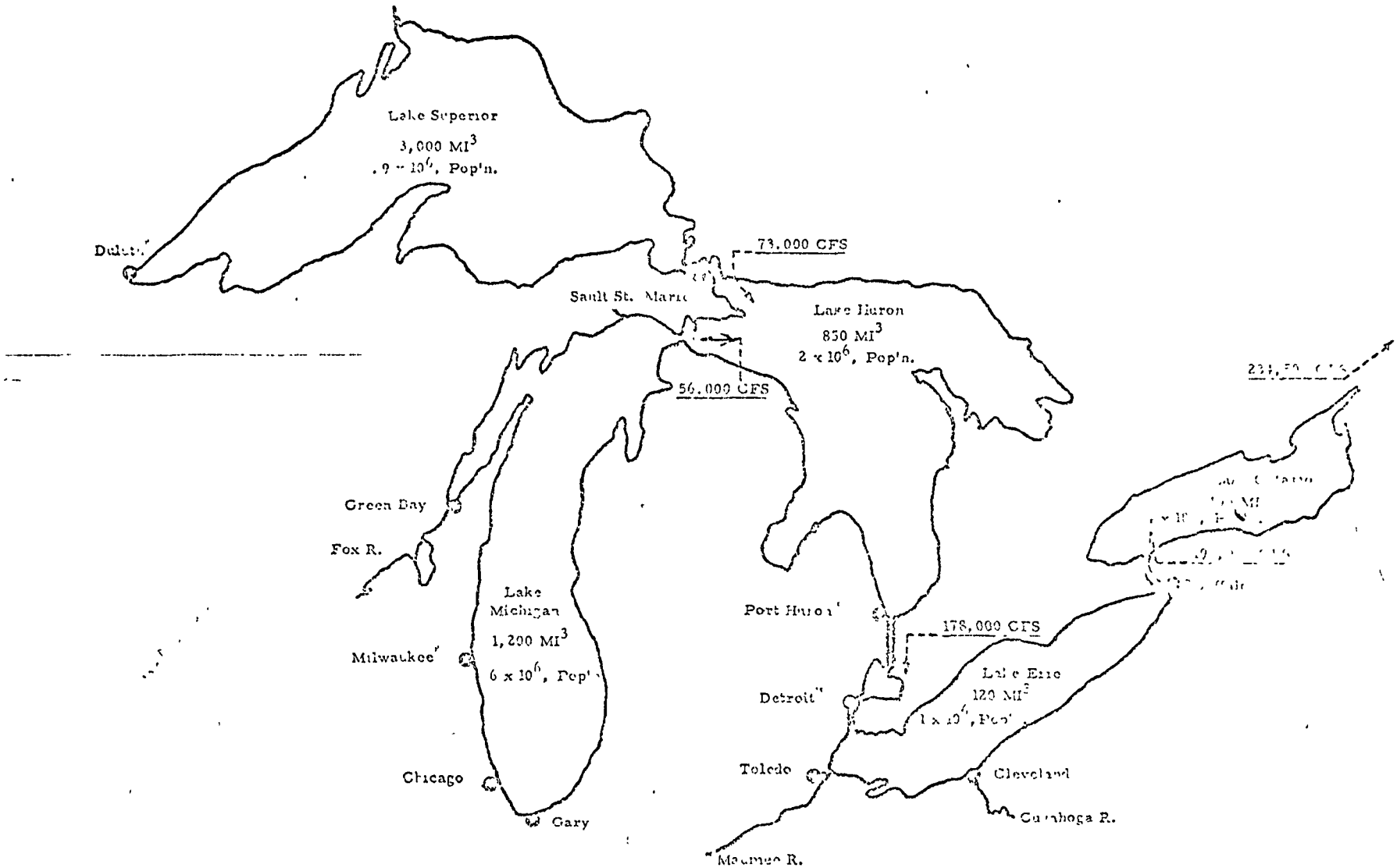
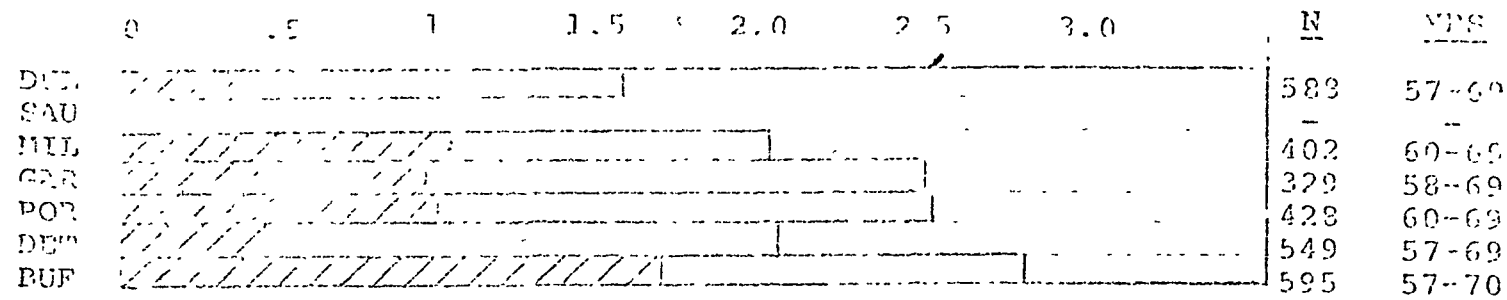


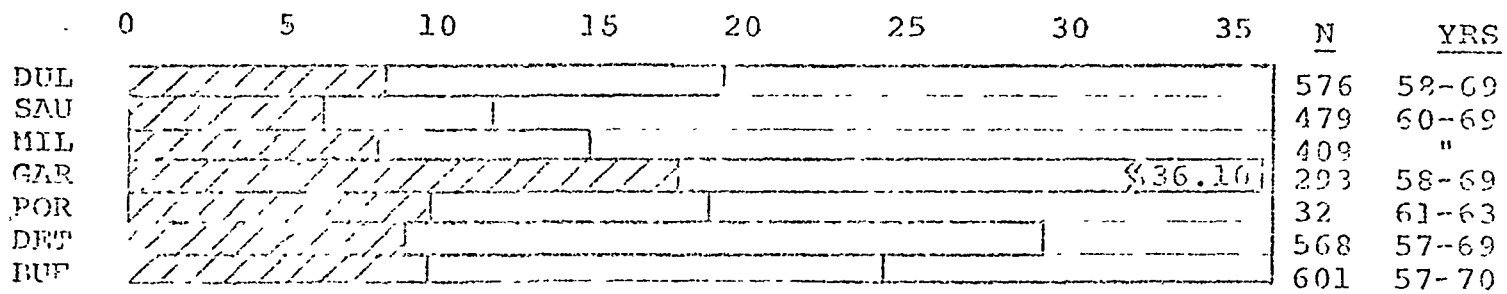
FIGURE OVERVIEW OF THE GREAT LAKES

FIG. 6 -- WATER QUALITY PARAMETERS FOR GREAT LAKES (PPM)

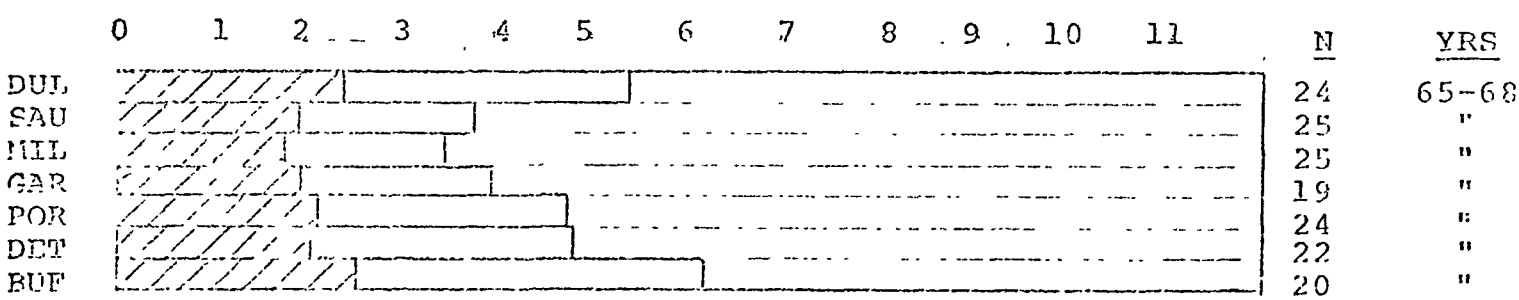
BIOCHEMICAL OXYGEN DEMAND, 5 DAY (ppm)



CHEMICAL OXYGEN DEMAND, LOW LEVEL (ppm)



DISSOLVED ORGANIC CARBON (ppm)

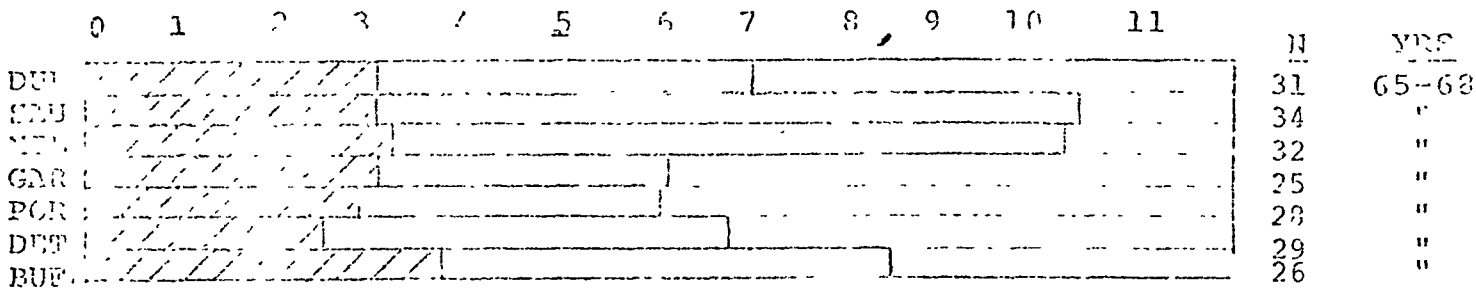


Mean Concentration Mean + 2 Std. Dev.

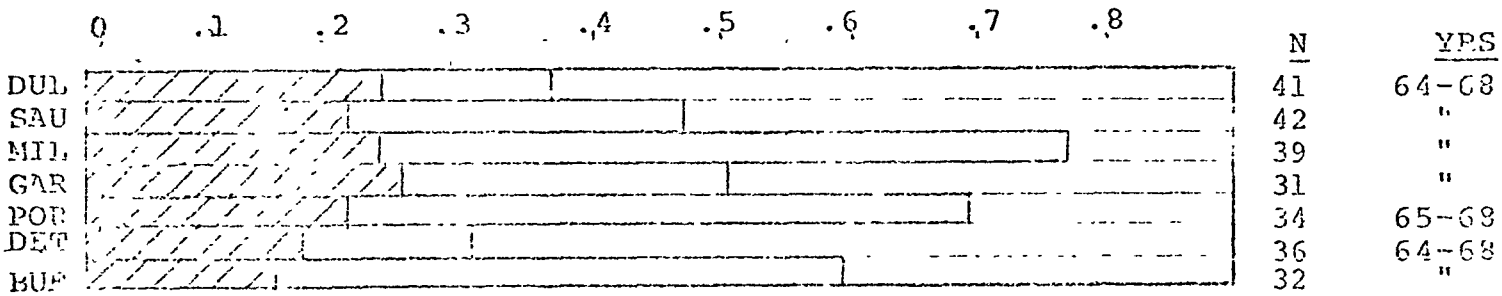
DUL = Duluth
SAU = Sault St. Marie
MIL = Milwaukee
GAR = Gary, Ind.
POR = Port Huron
DET = Detroit
BUF = Buffalo

[illegible] FOR THE GREAT LAKES (PHS)

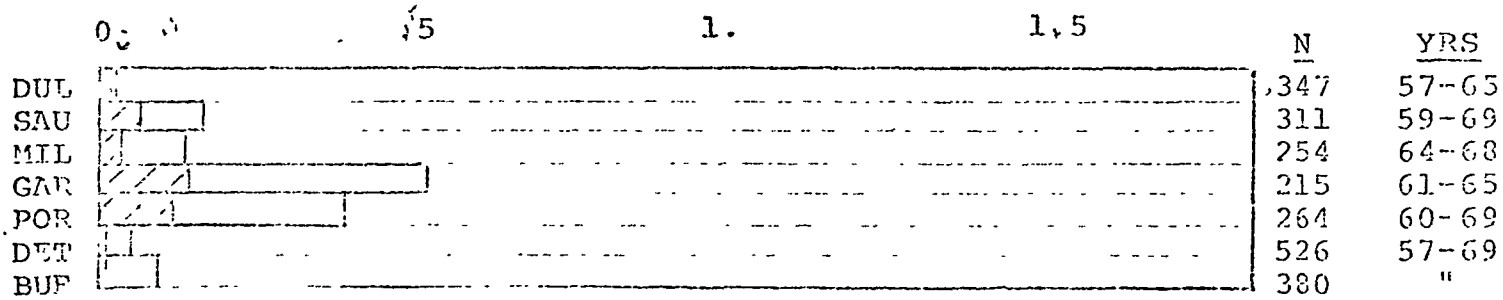
TOTAL ORGANIC CARBON (ppm)



NITRITE & NITRATE NITROGEN (ppm)



AMMONIACAL NITROGEN (ppm)



////// Mean Concentration ---------- Mean + 2 Std. Dev.

DUL = Duluth
SAU = Sault St. Marie
MIL = Milwaukee
GAR = Gary, Ind.
POR = Port Huron
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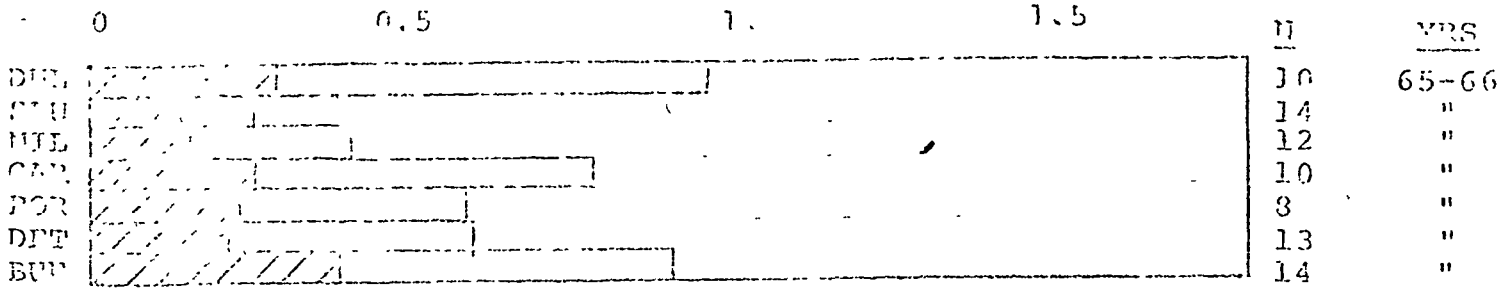
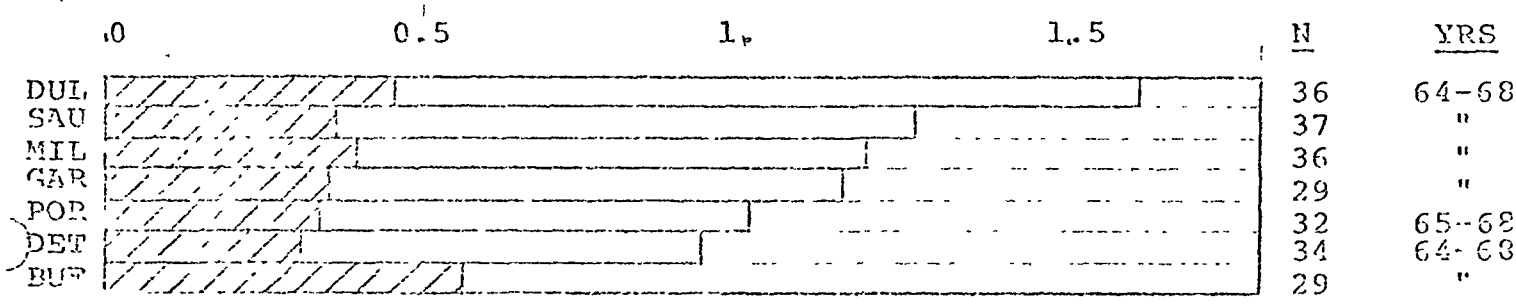
BUF = Buffalo

FIGURE [illegible] - [illegible] OF [illegible] LEAGUE TOWNS
FOR THE GREAT LAKES (1968)

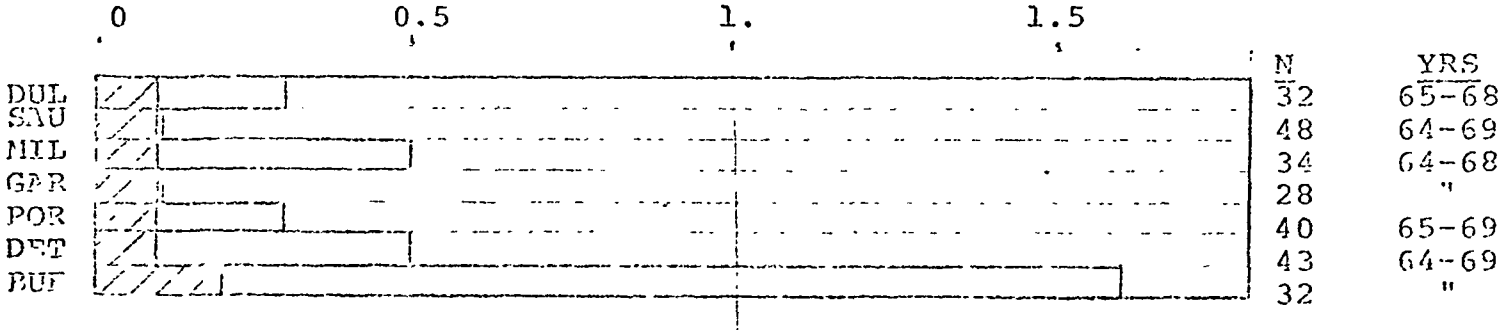
DISSOLVED AMMONIACAL & ORGANIC NITROGEN (ppm)



TOTAL AMMONIACAL & ORGANIC NITROGEN (ppm)



DISSOLVED PHOSPHORUS (ppm)

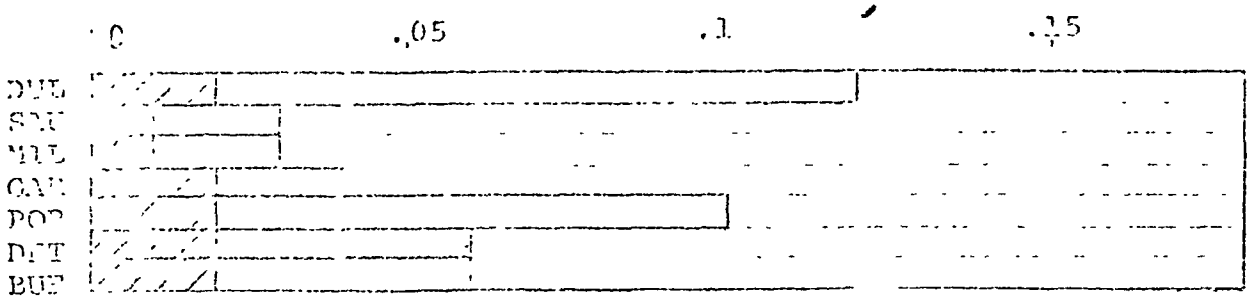


////// Mean Concentration - - - - Mean + 2 Std. Dev.

DUL = Duluth
SAU = Sault St. Marie
MIL = Milwaukee
GAR = Gary, Ind.
POR = Port Huron
DET = Detroit
BUF = Buffalo

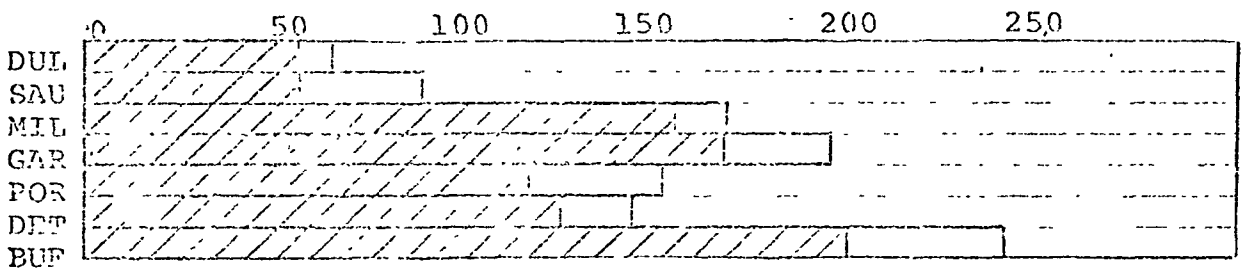
FIGURE - WATER QUALITY MEASUREMENTS
FOR THE GREAT LAKES (GLOS)

TOTAL PHOSPHORUS (ppm)



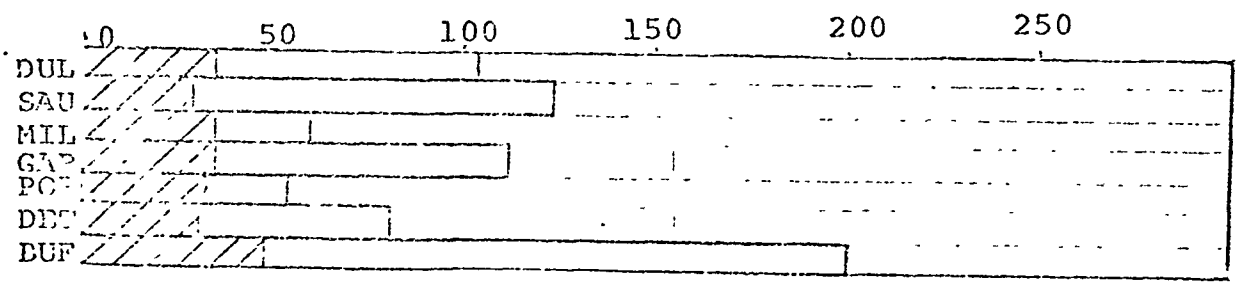
	N	YRS
DUL	40	64-68
SAU	49	64-69
MIL	38	64-68
GAR	28	"
POR	42	65-69
DET	32	"

TOTAL DISSOLVED SOLIDS (ppm)



	N	YRS
DUL	577	57-69
SAU	29	61-69
MIL	422	60-69
GAR	344	58-69
POR	374	61-69
DET	570	57-69
BUF	589	58-70

SUSPENDED SOLIDS (ppm)



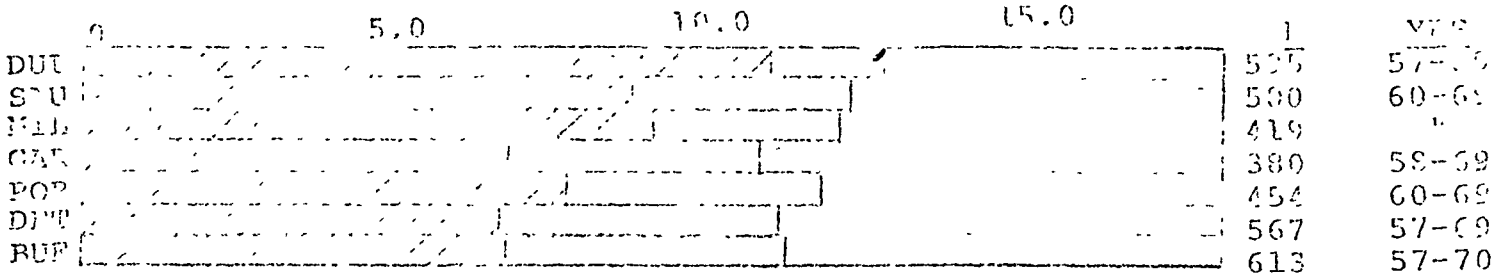
	N	YRS
DUL	185	59-69
SAU	126	59-69
MIL	126	60-64
GAR	139	59-64
POR	138	60-64
DET	164	59-69
BUF	156	59-64

////// Mean Concentration Mean + 2 Std. Dev.

DUL = Duluth
SAU = Sault St. Marie
MIL = Milwaukee
GAR = Gary, Ind.
POR = Port Huron
DET = Detroit
BUF = Buffalo

FIG. [illegible] -- [illegible] OF [illegible] ELEMENTS
FOR [illegible] OF [illegible] LAKES (PHS)

DISSOLVED OXYGEN (PPM)



////// Mean Concentration ------- Mean + 2 Std. Dev.

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TABLE - RELIABLE EVIDENCE OF OPEN WATER QUALITY CHANGES IN THE GREAT LAKES, 1930 - 1970 (% CHANGE)

	SEDIMENT CONSTITUENTS	TOTAL N	TOTAL P	O_2 DEPLETION	NO_3	SO_4	Cl	Na & K	[illegible]
SUPERIOR	-	-	-	-	-	0	0	0	-6
MICHIGAN	-	-	-	-	0	+20	+125	-	+[illegible]
HURON	-	-	-	-	-	+25	+70	0	[illegible]
ERIE	-	-	-	+110	-	+40	+160	+40	+[illegible]
ONTARIO	-	-	-	-	-	+60	+160	+45	-

TABLE - CHLORINATED HYDROCARBONS IN THE GREAT LAKES

	% FISH CATCH ≥ 5 ppm DDT BAN	TYPICAL DDT IN FISH (ppm)	TYPICAL PCB IN FISH (ppm)	TYPICAL DDT, DDT (ppt)	[illegible]
SUPERIOR	8% (trout)	-	-	-	-
MICHIGAN	80% (total)	4-20	8-30	1-10	1-30
HURON	-	1*	11*	-	-
ERIE	claimed small	-	-	-	-
ONTARIO	-	2*	12*	-	-

* INADEQUATE SAMPLE

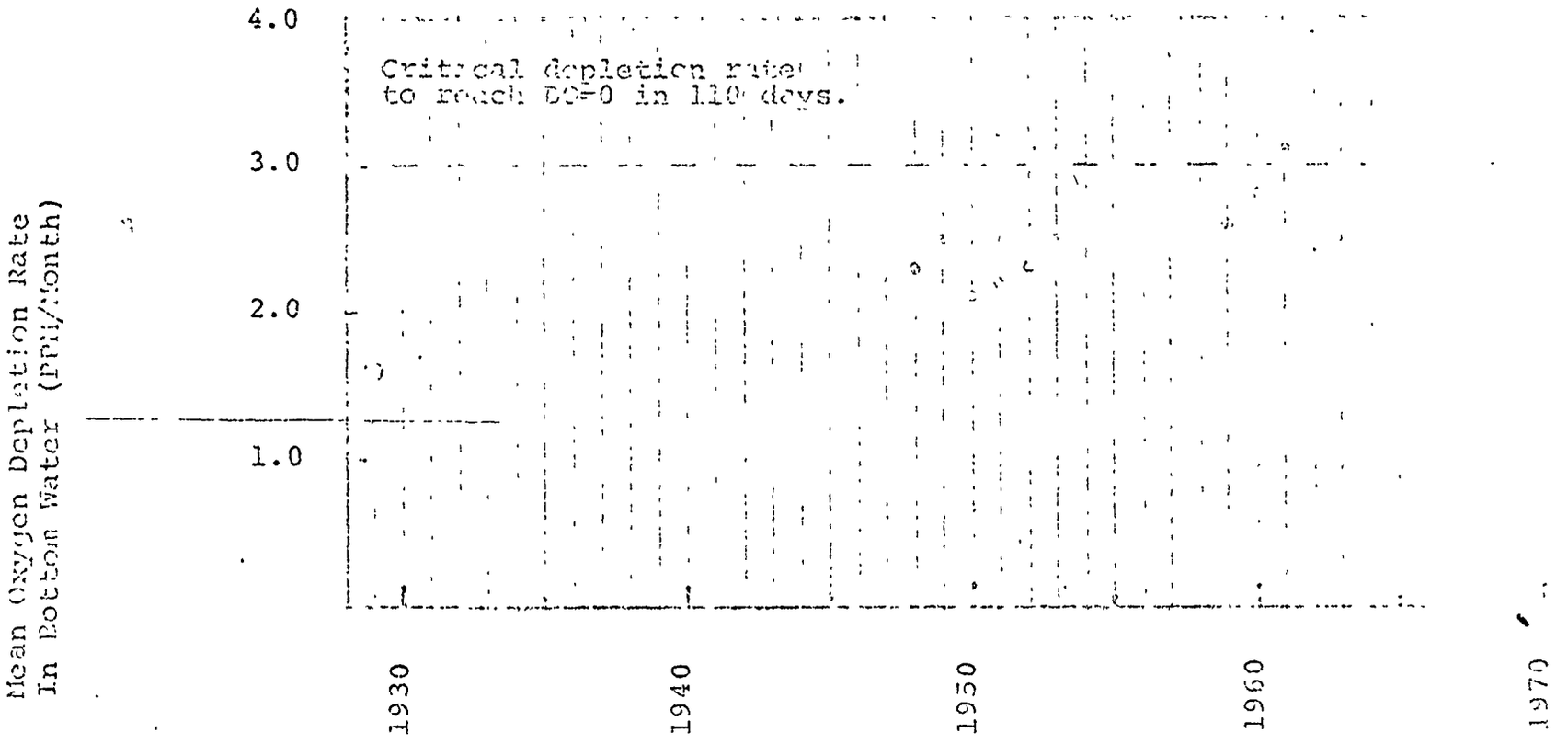


FIGURE - OXYGEN DEPLETION RATE HISTORY FOR LAKE ERIE CENTRAL BASIN BOTTOM WATER

ESTIMATED PHOSPHORUS BUDGETS FOR LAKE ERIE

	FWPCA ('68)		IJC ('69)		ALTERNATE	
	LBS/DAY	%	LBS/DAY	%	LBS/DAY	%
MUNICIPALITIES [1]	93,400	60%	100,000	62%	72,000	45%
INDUSTRY	6,900	4	10,000	6	7,000	4
AG + OTHER RUNOFF	36,980	23	39,000	24	70,000	43
LAKE HURON DISCHARGE	20,000	13	12,000	8	12,000	8
	157,280	100%	161,000	100%	161,000	100%

[1] INCLUDES CANADA

[illegible]

a. [illegible] - [illegible] state [illegible] approx. 50 [illegible]. Erie [illegible] is [illegible] [illegible] [illegible] only a [illegible] and Erie [illegible] major discharges.

b. WQ knowledge - Pa. is defacto effluent State, despite [illegible] [illegible] ambient monitoring at scattered sites.

c. Discharger knowledge - Pa. cannot perform usable, thorough effluent surveys (e.g. Erie, Calsicat) though files are bulging. Few flow measurements. WMIS computer system almost unreadable.

d. Load allocations - based on "practical" technology, do not consider WQ.

e. Inspection and enforcement - little usable inspection, uninpressive and agressive Environmental Strike Force with well-developed procedures; trivial fines.

f. WQ after compliance - no knowledge.

TABLE - PENNSYLVANIA : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER(%)	PARAMETERS WORSE(%)	NO TREND TOO AVAILABLE	NO TREND INSUFFICIENT DATA	NO TREND [illegible]
HAMMERMILL	69-70				DOD COD Hg	
ERIE STP	JAN.65-NOV.70 JAN. -NOV.70					DOD
CALSICAT	70				SS Hg	

3. [illegible] - [illegible]

a. General - Ohio has highly industrialized Erie Basin with complex [illegible], Toledo and Cleveland. Maumee is largest [illegible] in lesser; rapidly growing [illegible] to St. Lawrence Seaway. Moderately large staff; frequent reorganization, pervasive chaos. Latest reorganization is Ohio EPA.

b. WQ knowledge - little monitoring except by USGS (with usual emphasis on hardness and silt).

c. Discharger knowledge - 1952 Permit Law, good files, very slow sign-up. Halted for 18 months. 15 years to sign-up Firestone, Goodrich, and Goodyear. Don't use self-reports (e.g. Republic) nor do they verify them. Many poor STP inspections; several superb. Throw away all data older than 5 years.

d. Load allocations - no consistent basis found. Recently use very tough language in permits even with highly compliant industries (e.g. SOHIO at mouth of Maumee).

e. Inspection and enforcement - excellent reports on Cleveland's many deficiencies - no action. Sewer has widely circumvented. Astounding case of Cleveland's "shower curtains". Little action on even flagrant industries or municipalities; however, OWDA operates with considerable efficiency in funding grants.

f. WQ after compliance - no notion except via USGS and self-reports.

TABLE - OHIO : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR MAJOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER(%)	PARAMETERS WORSE(%)	NO TREND TOO VARIABLE	NO TREND INSUFFICIENT DATA
JONES & LAUGHLIN STL.	JAN-JULY 1972				SS OIL
SOHIO	60-70	OIL(70%) NH_3(80%)	SS(50%)		
CLEVELAND SOUTHERLY STP	51-72		BOD(200%)	SS	NH_3 NO_3 TOT.PO_4
CLEVELAND WESTERLY STP	MAR-JULY 1972				BOD COD [illegible] TOT.PO_4 NH_3 ORG. N NO_3
CLEVELAND EASTERLY STP	49-72		BOD(300%) SS(100%)		COD TOT.PO_4 NH_3 NO_3
INTERLAKE STEEL	67-72				COD SS NH_3 Cl Fe TOT.PO_4 SO_4 Cl

TABLE - OHIO (CONT'D) : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR MAJOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER (%)	PARAMETERS WORSE (%)	NO LIMIT TOO VARIABLE	NO LIMIT INADEQUATE DATA	[illegible]
DIAMOND SHAMROCK,	NOV 68 to MAY 72	NH_3 (25%) SS (50%)				[illegible]
AKRON STP	48-70		SS (50%)			[illegible]
TOLEDO STP	51-70	BOD (70%)		SS		
FIRESTONE TIRE & RUBBER	68-72				COD TS Cr	
US STEEL	OCT 67 to SEPT 69	OIL (90%) Fe^{++} (95%) TOT.Fe (90%) SO_4 (70%)	Cl (40%)	SS		

1. [illegible]

a. General - [illegible], only very small drainage to Great Lakes ([illegible], [illegible], two U.S. Steel plants, Fansteel, Outboard Marine). Storm overflow of Chicago and Calumet Rivers probably major pollutant input but unknown. Illinois EPA vs. MSD is excellent instrument of delay.

b. WQ knowledge - small amount of monitoring accomplished, results unavailable due to reorganization, chaos, new computer system.

c. Discharger knowledge - major files misplaced (e.g. South Works, U.S. Steel, Fansteel, etc.). Extremely sparse State measurements: usually omit flow; normally look for wrong pollutants (e.g. Fansteel's tantalum, titanium, molybdenum and non-existent BOD).

d. Load allocations - prefer effluent standards (short list of maximum concentrations); requirements not explicitly related to WQ since discharges are so near Lake.

e. Inspection and enforcement - very low field effort (2 men with buckets until last year). IEPA tries cases before Pollution Control Board; several cases sent home for lack of evidence. MSSD sewer bans resulted in a first variance allowing 20,000 people to hook up. Massive IEPA vs. EPA vs. Abbott confusion over non-existent testing requirements. Similar EPA warning to steel companies on Calumet over non-compliance with non-existing standards.

f. WQ after compliance - data not retrievable; no knowledge.

TABLE - ILLINOIS : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR MAJOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER (%)	PARAMETERS WORSE (?)	NO TREND TOO VARIABLE	NO TREND INADEQUATE DATA	[illegible]
US STEEL WAUKEGAN	FEB.-MAR.69				SS Fe TS	
FANSTEEL METAL CORP.	MAR.-AUG.72				SS METALS	
NSSD WAUKEGAN	JAN.71-JAN.72				BOD TS	
NSSD NORTH CHICAGO	69-71				BOD SS	
NSSD CLAVEY ROAD	JAN.-OCT.71				BOD SS	

5. [illegible] - [illegible]

a. General - sparsely populated Lake Superior drainage basin (240,000). Largest river is St. Louis (Duluth). Basin is forested, steep and based on weathered, half billion year old Precambrian rock.

b. WQ knowledge - only four stations in Basin. Frequent shifting and reorganizing. One year hiatus to write standards. Data is available. No station in Lake near Duluth, despite obvious pollution.

c. Discharger knowledge - no State data at all on any discharger, municipal or industrial. Only two industrial self-reports, Reserve and Superwood. Even data-free lists of dischargers omit more than half of the larger towns in the Basin, not to mention U.S. Steel, Union Carbide, Continental Oil and the USAF. No info at State on 1800 mines - not even whether operating or closed.

d. Load allocations - State has promulgated effluent standards - the SS standard is basis of Reserve case (1969).

e. Inspection and enforcement - no record of any inspections. All State effort went into Reserve case - State lost. No towns other than company towns have secondary treatment or phosphorus removal; even Duluth remains unscathed.

f. WQ after compliance - this capability remains untested.

6. INDIANA - [illegible]

a. General - Drains via [illegible] to Erie, via St. Joseph [illegible] and [illegible] to Michigan from the big industrialized strip around Gary. State programs in air, water, [illegible] and solid waste, through organizationally separate, were run by one man until recently. More powerful legal authorities than any other State.

b. WQ knowledge - best run and sited monitoring system in the Great Lakes (100 bi monthly stations) - fully published and even include stream flow.

c. Discharger knowledge - only State emphasizing large dischargers; relay on self-reporting which is not formally verified. Excellent STP surveys.

d. Load Allocation - no formal system though intensive reach surveys are done (but not published). Use only professional judgement.

e. Inspection and enforcement - Indiana does not use permit power; it enforces only through plan review. Almost no cases come to court - compliance good on cases reviewed. Almost every important town has secondary, most since late forties. However, little emphasis since last round of cleanup in Gary despite major load increases.

f. WQ after compliance - State certainly has data to determine WQ improvements; not known whether data is used for this purpose.

TABLE - INDIANA : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR MAJOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER (%)	PARAMETERS WORSE (%)	NO TREND TOO VARIABLE	PARAMETERS INADEQUATE DATA	[illegible]
INLAND STEEL CO.	63-72				BOD COD O[illegible] SS SO_4 NH_3 Fe CN	
AMERICAN OIL CO.	65				BOD/PHENOL COD SS OIL NH_3 ORG N NO_3	
EAST CHICAGO STP	71-72				COD SS NH_3 Cl	
GARY STP	67-72		BOD (150%) SS (20%)			
SINCLAIR OIL	65-67				BOD OIL NH_3 PHENOL	

7. MICHIGAN - [illegible]

a. General - most important part of Michigan drains to Lake Erie (most of industry and 40% of population around Detroit). All State agencies have excellent ability to obtain Federal funds. Agency prepares cases, State AG prosecutes.

b. WQ knowledge - technically sound WQ standards. Stations shift often; no regular publication available. Excellent though sparse spot surveys (best surveys in the Basin). Poor State-wide coverage.

c. Discharger knowledge - excellent knowledge of those dischargers surveyed. Require self-reporting for permits (recently) - few permits issued. Have many major dischargers, including those complying under old orders, with zero effluent data (Welch's, Gerber's, Huron Portland Cement, Michigan Milk Producer's Assoc.)

d. Load allocations - use WQ and occasionally computer BOD/DO models. More sophisticated than any other State; applications have grave flaws (fail to measure to sag point, confound various BOD sources, "estimate" reaction at dams). Other allocations done on usual primitive basis.

e. Inspection and enforcement - superb inspection and case preparation; almost no enforcement (AG provides 1-1/2 - 3 manyears/year). Attempted to fine McClouth, after 40 spills, $20,000. Court awarded $500 with $300 suspended for good intentions. Hercules prevented from land disposal by courts. Sault St. Marie very instructive case on EPA vs. Michigan. Effluent loads have decreased for Hercules and two sugar companies.

f. WQ after compliance - two cases where improved DO was claimed but was actually due to temperature being cooler on the checkup survey. Normally State never goes to look afterward.

TABLE - MICHIGAN : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR MAJOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER (%)	PARAMETERS WORSE (%)	NO TREND TOO VARIABLE	NO TREND INADEQUATE DATA	NO [illegible]
MCLOUTH STEEL	62-71				BOD COD SS PHENOL Fe	
DUNDEE CEMENT	60-66				BOD SS	
HERCULES, INC	47-72	BOD (80%) SS (50%)			TOT. PO_4	
MONITOR SUGAR	49-70				BOD SS	
CELOTEX	60-64				BOD SS	
GREAT LAKES STEEL	65-70	PHENOL (90%) Fe (70%)				
DETROIT STP	65-70	TOT. PO_4 (80%)	BOD (10%) SS (80%) PHENOL (50%)			
MONROE STP	65-70	BOD (50%)	SS (100%) TOT. PO_4 (20%)			
CONSOLIDATED PKG.	65-70	BOD (25%) SS (20%)				

5. Fl[illegible]

a. General - Important dairy and paper industries [illegible] to Lake Michigan. [illegible] as defacto [illegible] shed. [illegible] adjacent to [illegible] personnel. Switched from effluent to WQ standards.

b. WQ knowledge - Wisconsin has excellent simple series of basin reports (30 + basins) summarizing WQ and discharger knowledge for ambient, effluent (mostly BOD and SS) and biological measurements. Repeated every 4-7 years. Also has fixed stations. Does more pesticide monitoring than any other State in Basin. Uses wardens, etc.

c. Discharger knowledge - see above.

d. Load allocations - based on extremely primitive method but generally reasonable. Required turbine stream reaeration in early sixties with good results.

e. Inspection and enforcement - inspects on 4-7 year cycle - quite thoroughly even down to land disposal drainage. Rarely goes to court despite best compliance record in Basin (particularly municipalities). Wardens made 183 arrests in two years. Has even enforced on dieldrin violation by wool mill. Only State with full phosphorus removal compliance. Racine is good case of delay due to regulations.

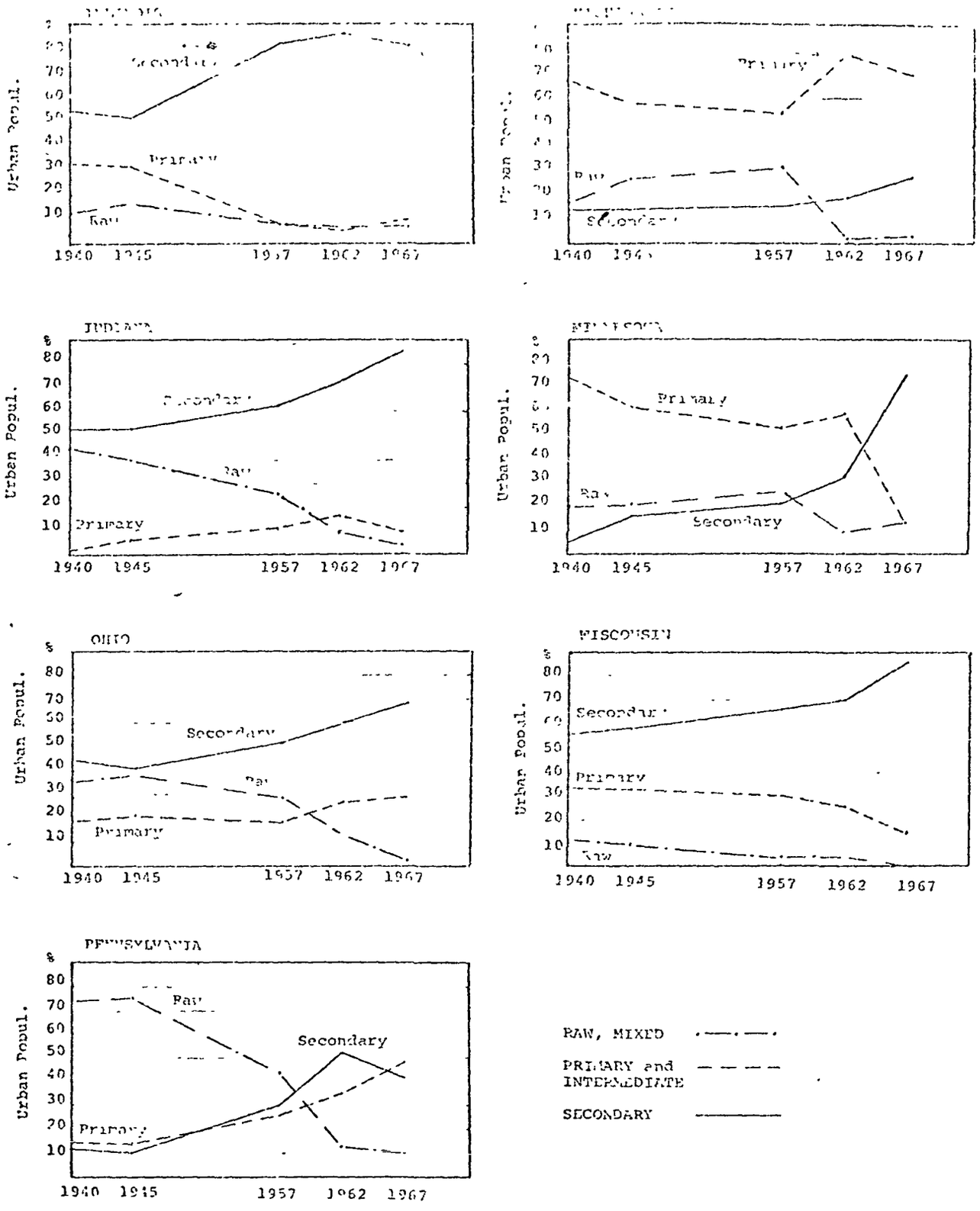
f. WQ after compliance - based on same 4-7 year cycle, basin reports show WQ and biota changes since last report as well as total effluent trend.

TABLE - WISCONSIN : SUMMARY OF EFFLUENT DATA
AVAILABLE AT STATE LEVEL FOR MAJOR DISCHARGERS

DISCHARGER	PERIOD	PARAMETERS BETTER(%)	PARAMETERS WORSE(%)	NO TREND TOO VARIABLE	[illegible]
RACINE STP	66-72	BOD (50%)			
	DEC.-Mar.72	SS (20%)			
SCOTT PAPER					
OCONTOFALLS	52-67	BOD (40%)			SS
MARINETTE	52-67		BOD (200%)		
			SS (100%)		
MILWAUKEE STP	JAN.-OCT.70				BOD
					SS
KIMBERLY-CLARK					
NEENAH	56-72	SS (95%)			BOD
NIAGARA	57-68	BOD (30%)			
GREEN BAY STP	56-63		BOD (300%)		
			SS (400%)		
SUPERIOR FIBER PROD.	65-66				BOD
SUPERIOR STP	66-71	BOD (30%)			
KENOSHA STP	54-67	BOD (70%)			
SHEBOYGAN STP	51-70	BOD (30%)			
OSHKOSH STP	52				BOD

TABLE - WISCONSIN: SUMMARY OF TOTAL BOD
(LBS/DAY - PEAK SEASON) DISCHARGED TO STREAM, 1930 - 1961

	1930	1949	1954	1961
Milk	42,500	32,700	26,700	7,400
Cannery	161,000	74,100	40,300	18,700
Pulp & Paper	518,000	857,000	943,000	8[illegible],000
Misc. Industry	47,500	10,000	8,700	25,000
Municipal	239,000	231,000	202,000	207,000
Total	1,010,000	1,210,000	1,220,000	1,130,000



SEWAGE TREATMENT LEVEL AS REPORTED BY STATES FOR THE YEARS LISTED. TREATMENT BY PERCENT IS BASED ON LITERS POPULATION REPORTED SERVED OR ON URBAN POPULATION FOR THAT YEAR, WHICHEVER IS THE LARGEST NUMBER.
Data collected by USPHS and FWQA (1967).

[illegible] PLAN [illegible]

The attached table is derived from data submitted by the States in their Water Quality Management Program Plans. Useful comparisons between States cannot easily be made because several of the key quantities are undefined, including number of dischargers, number with treatment facilities, number inspected and number in compliance. A glance at the table shows that the States vary considerably even in their definition of a discharger. For instance, New York claims only 561 municipal dischargers while Pennsylvania has 1,860 and Illinois has 1,496. The definition of what constitutes a treatment facility for an industrial discharger is equally suspect, since it could range from a coarse screen to a full certiary plant. Needless to say, the most suspect categorization of all is the "in compliance" definition.

As a result of these loose definitions, only the grossest impressions can be drawn from the State Program Plan data, as summarized below:

1. Budget effort and allocation: In terms of absolute water program size, Pennsylvania and New York have by far the largest program with 373 ($4.0M) and 216 ($4.7M) man years respectively, though New York spends more than Pennsylvania. This is at least double the size of the other states' programs, which are typically between 85 and 115 man years, except for Illinois at 154 and Indiana at a notably low 63 man years. Most States show fairly insignificant changes from FY71 to FY72, except for Minnesota, Ohio and Pennsylvania

which the water program manpower increased of 45 to 60%. New York's manpower trend cannot be assessed due to accounting changes though its budget has increased 40%. Most States have relatively equal size air and water programs, except for Illinois, Ohio and New York where air runs 2 1/2 to 3 times larger than water. In terms of water program expenditures per $1000 of personal income, the highest spenders are Pennsylvania, Minnesota and Wisconsin at 33 to 38¢ per capita per year. The lowest spenders are Ohio and Indiana at 10¢ per capita with Illinois only slightly higher at 16¢.

2. Budget allocation: Percent of water program manpower reported as spent on surveillance and enforcement is remarkably constant in time for all States. Furthermore, all spend about 50% of their manpower in this activity, except for Minnesota and Pennsylvania (35%) and New York which uses only 25% of its manpower in surveillance and enforcement. Note that all three of these States are badly in need of better affluent and stream quality data. On an effort per permittee basis, Pennsylvania and Michigan are highest with .08 to .11 MY'S while Indiana, Wisconsin and Ohio are low at .03 to .04 MY'S per permittee--an interesting finding since Wisconsin has probably the best knowledge of its dischargers and its stream quality of any of the States while Ohio has among the worst.

The two major categories of State activity are Facilities (engineering and review of treatment plants) and Planning (studies, modelling projections, etc.) Differences in Planning percentage allocations, needless to say, may be as much a function of accounting definitions as of actual effort (particularly in view of the fact that EPA repeatedly urges most of the Great Lakes States to do more planning). In any case, Indiana, Michigan and Ohio show notably low manpower efforts, 3 to 6%, while Wisconsin and New York show 22% with New York using 32% of budget dollars in this category. Clearly, reported planning effort is not correlated with results.

Facilities manpower allocation is not quite as variable among the States as Planning. The high States are New York (44%) and Illinois (35%); the rest are 20 to 30% with Michigan notably low at 12% of manpower in Facilities. On the basis of man year per municipal STP, New York is far and away the highest with .17 MY'S per STP; the rest run .03 to .05 MY'S except for Illinois at .02. Again, we see no correlation between achieving widespread satisfactory municipal treatment and manpower allocated since New York has an unusually low number of reported STP'S, whereas the States that have achieved reasonable secondary treatment in most major cities, Wisconsin and Indiana, have only median manpower efforts.

3. Municipal activity: All [illegible] notably high percentages (at least 90%) of municipalities report it to have treatment (mostly primary) except for Illinois which has only half of its municipalities showing any treatment. Almost all STP'S are under some type of state order, permit or review (of variable quality) and have at least annual inspections (of variable competence). Indiana, Wisconsin and Michigan inspect at least twice per year (and with considerable competence).

4. Industrial activity: Only Indiana and Wisconsin have at least 80% of their dischargers under orders or with approved plans (and with similarly high percentages of dischargers treating). Illinois and New York have only 11 to 15% of industrial dischargers treating-the rest run 60 to 80%. Illinois, Minnesota, Michigan and New York have notably low percentages of industrial dischargers covered by permits-about 20 to 35%. Again, Illinois and Minnesota achieve the lowest amount of inspection of industrial permittees-the rest have good coverage, though varying competence.

The conclusion drawn from this data is that minimal useful information, in the form that it now appears is transmitted to EPA. It is apparent that there is no significant correlation between dollars budgeted, MY'S expended, and water pollution abatement. Little emerges that can usefully be related to the problem of water pollution in the reporting states.

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	72%	[illegible]	[illegible]	73%	[illegible]	[illegible]
[illegible] 1/	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 1/	[illegible]	12% 1/	[illegible]	[illegible] 1/	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	57/6[illegible]	96/11[illegible]	[illegible]6/65	300/216	60/67	281/273	[illegible]
[illegible] 2/ [illegible]	[illegible]	.72/.7[illegible]	1.2/1.9	81/3.5	4.1/5.3	1.3/1.5	3.1/1.6	[illegible]/1.9
PER CAPITA [illegible] 53000 [illegible] (10^{-3})	[illegible]	3.9	5.2	10.	6.	3.4	9.6	11.3
% $ [illegible]	13%	3.3.	4.3%	12%	32%	6%	15%	25%
% MY'S IN [illegible]	14%	2.9%	4.3%	14%	22%	6%	15%	[illegible]
% MY'S IN SUBMERGENCE	51%	49%	63%	35%	25%	49%	36%	48%
% MY'S IN FAC ENG'G	35%	25%	12%	21%	44%	29%	21%	20%
SEAL MY'S PER PERMITTED 2/	.05	.03 4/	.31	.05 4/	.06	.03	.08	.04
FAC ENG'G MY'S PER MUN'L PLANT	.02	.05	.04	.04	.37	.03	.04	.03
MUNICIPAL ACTIVITY								
# MUNICIPAL DISCHARGERS CLAIMED	1426	317	313	487	561	UK	1060	650
% W/ TREATMENT	43%	85%	100%	95%	86%	83%	96%	100%
% UNDER PERMIT 2/	130[illegible]	100% 4/	100%	95% 4/	100%	97%	100%	100%
W/ PERMIT SUBMITTING REPORTS	60%	85%	100%	55%	90%	56%	84%	77%
% W/ TEMP. INSPECTED, FY71 (CRITO)	62% (1-2/yr)	95% (6/yr)	100% (2/yr)	100% (Unsch)	100% (1-/yr)	100% (1+/yr)	100% (2/yr)	100% (2/yr)
% COMPLIANCE CLAIMED	NL	71%	100%	--	76%	97%	82%	100%
INDUSTRIAL ACTIVITY								
# INDUSTRIAL DISCHARGERS CLAIMED	2556	UK	1013	762	1000	UK	2000	600
% W/ TREATMENT	11%	95%	58%	59%	15%	65%	80%	86%
% UNDER PERMIT 2/	26%	100% 5/	33%	19%	35%	83%	50%	81.5%
% W/ PERMIT SUBMITTING REPORTS	6 6%	14%	29%	68%	28%	60%	100%	43%
% W/ TEMP. INSPECTED, FY71 (CRITO)	32% (1-2/yr)	57% (4/yr)	100% (varied)	(Unchd)	85% (1/yr)	100% (1+/yr)	100% (2.5/yr)	100% (2/yr)
% COMPLIANCE CLAIMED	NL	69%	23% + 46% with accurate status rating	19%	34%	97%	70%	95%

1/ MUNICIPAL + INDUSTRIAL, GOVERNMENT FACILITIES, MISCELLANEOUS AND MIPS (PA.) INCLUDED.

2/ OR STATE CODES.

3/ STATE [illegible]

4/ NO PERMITS FOR SIP'S IN STATE; PAST [illegible] + MUNICIPAL DISCHARGERS W/ SIMPLE REVISED SIP'S.

5/ NO PERMITS FOR INDL SIP'S IN IND, PAST [illegible] + INDL DISCHARGERS WITH [illegible] REVISED SIP'S.

16. [illegible]

A. [illegible] 1933 to 1937 [illegible] the [illegible] Panel, the Natural Resources Committee board convened a [illegible] on Water Pollution reviewing all 48 states.

B. In 1937, the Panel identified major pollution problems on the Great Lakes (mostly municipal) and listed cities urgently needing treatment improvements. Each city named is still a major pollution problem, except for those in Wisconsin and Indiana which have essentially implemented the Panel's program.

C. We interviewed the Chairman of the Panel and asked him for salient impressions of the Great Lakes States. He felt that only Wisconsin had made notable progress with Indiana a distant second and the rest showing negligible progress. He noted the erratic and unreliable nature of the measurements collected by Pennsylvania's large field staff.

[illegible]

[illegible]

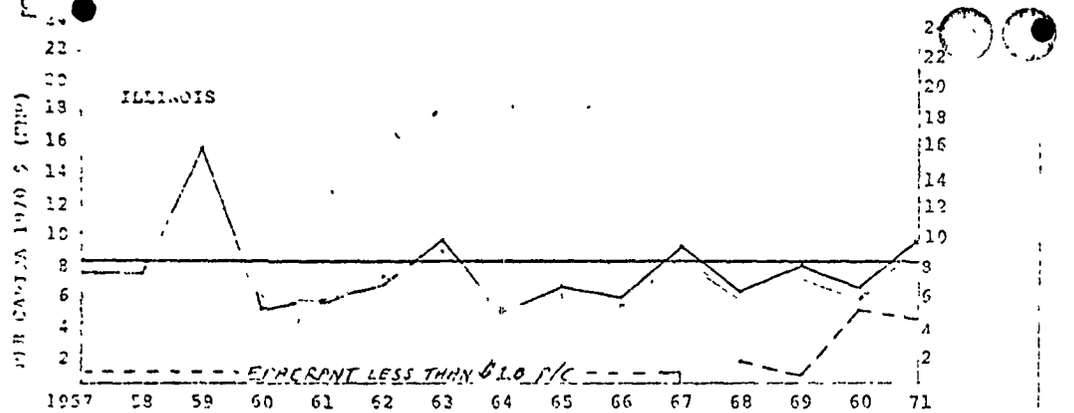
a. [illegible] the [illegible] Fed. [illegible] little insistence on [illegible] from failure.

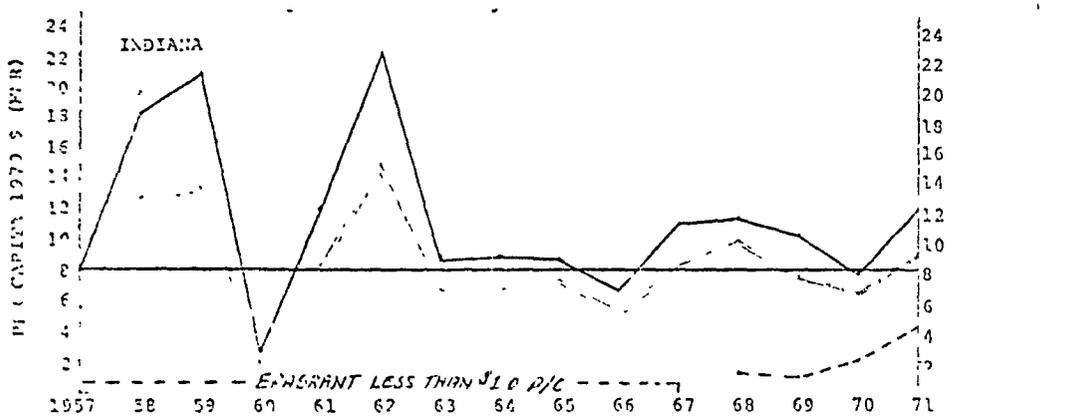
b. NQ Standards - this has probably been the most important and beneficial Federal impact under the old FWPCA.

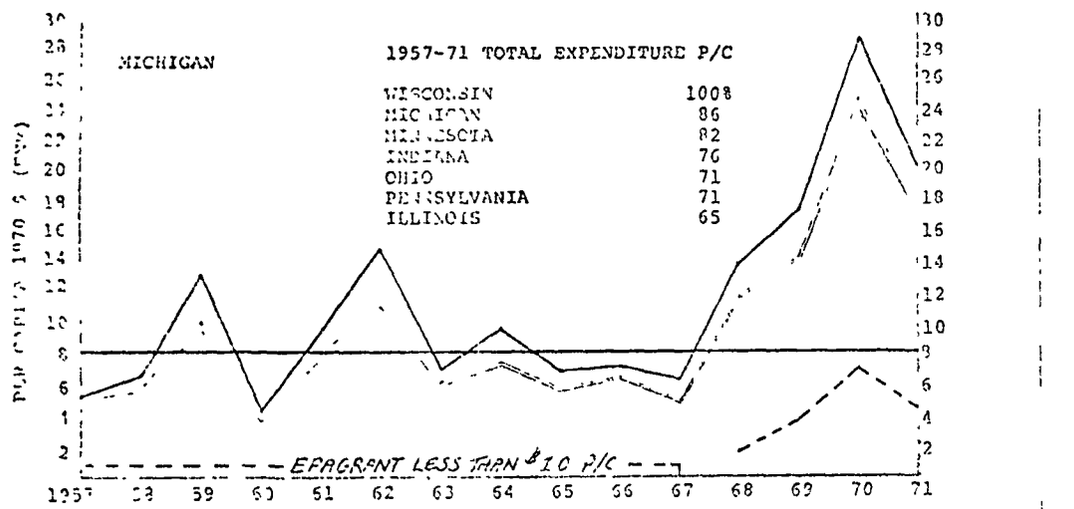
c. Leadership in Toxic Pollutants - where the Federal Program has emphasized important pollutants beside BOD and SS, real leadership has been exerted and good results obtained (e.g., mercury and pesticides, see Calcicat and fish bans).

d. Capitalizing on State Achievements - the Feds have missed a real opportunity in capitalizing on Indiana's monitoring system or Wisconsin's excellent basin survey/planning system - these would have been extraordinary examples for the other States. The emphasis on massive planning paperwork has not served the States well. At the same time, the Feds have failed to emphasize the really important weaknesses such as Michigan's lack of enforcement or Ohio's general crud or Minnesota's lack of any effluent data.

e. Diplomatic Relations with the States - there has been a notable deterioration in this area, much of it due to delays, some due to mere tone.



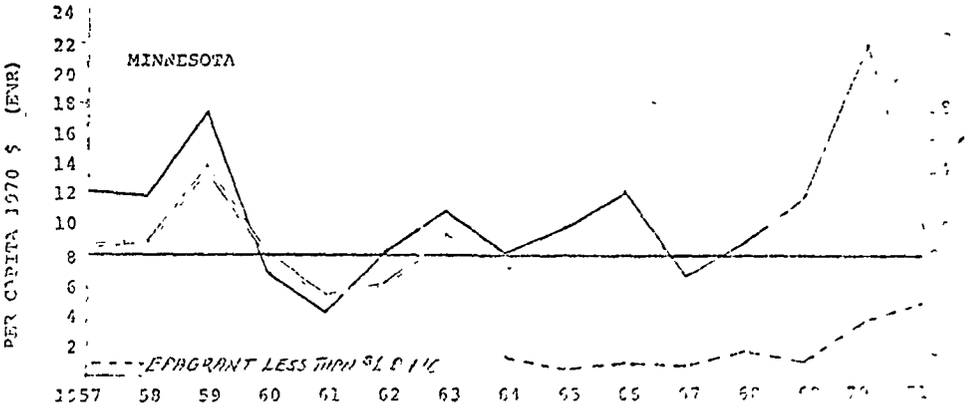


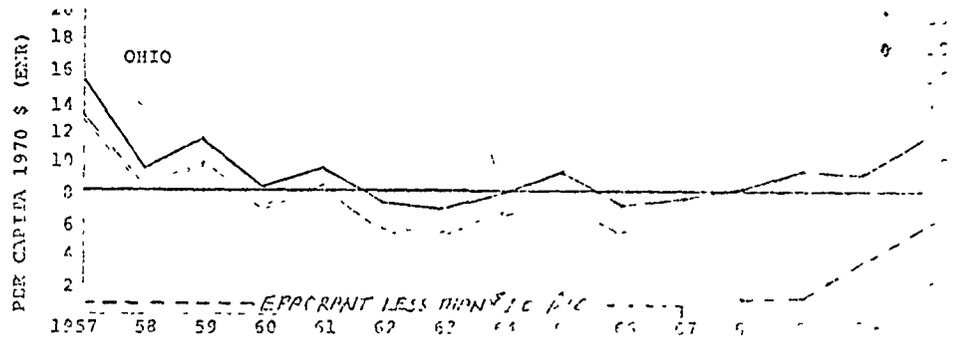


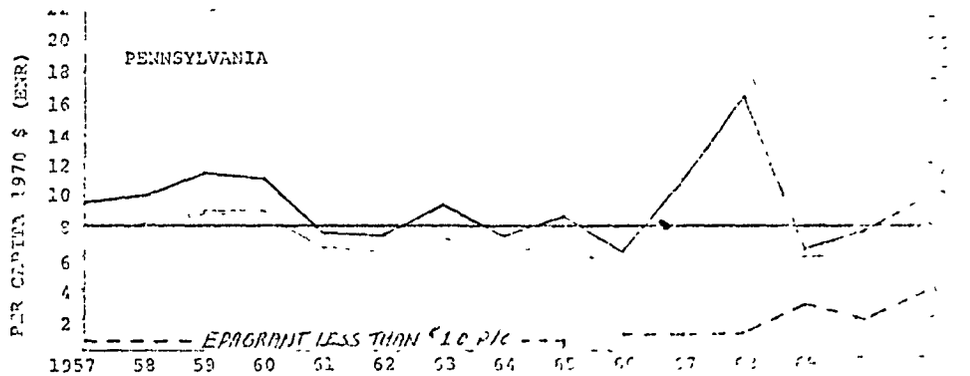
STATE P/C
UPEPP P/C
EPAGRANT P/C
*ONLY AWARDS TO TOWNS >2500

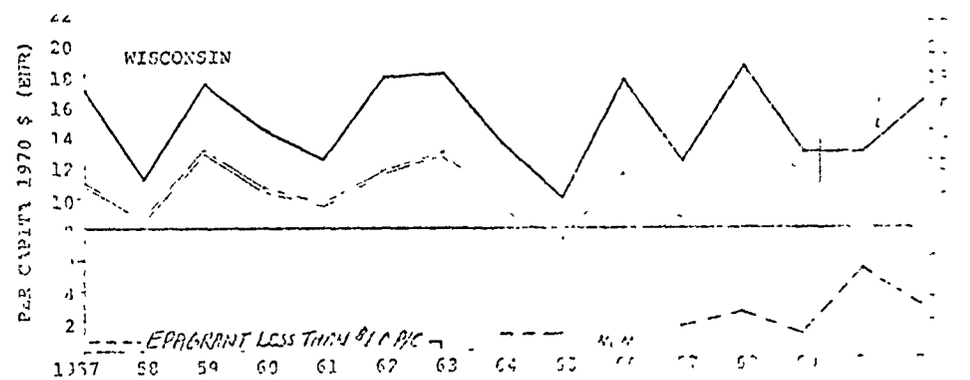
TOTAL CONTRACT AWARDS (SEWER AND STP) AND EPAGRANTS (STP) ON PER CAPITA BASIS.

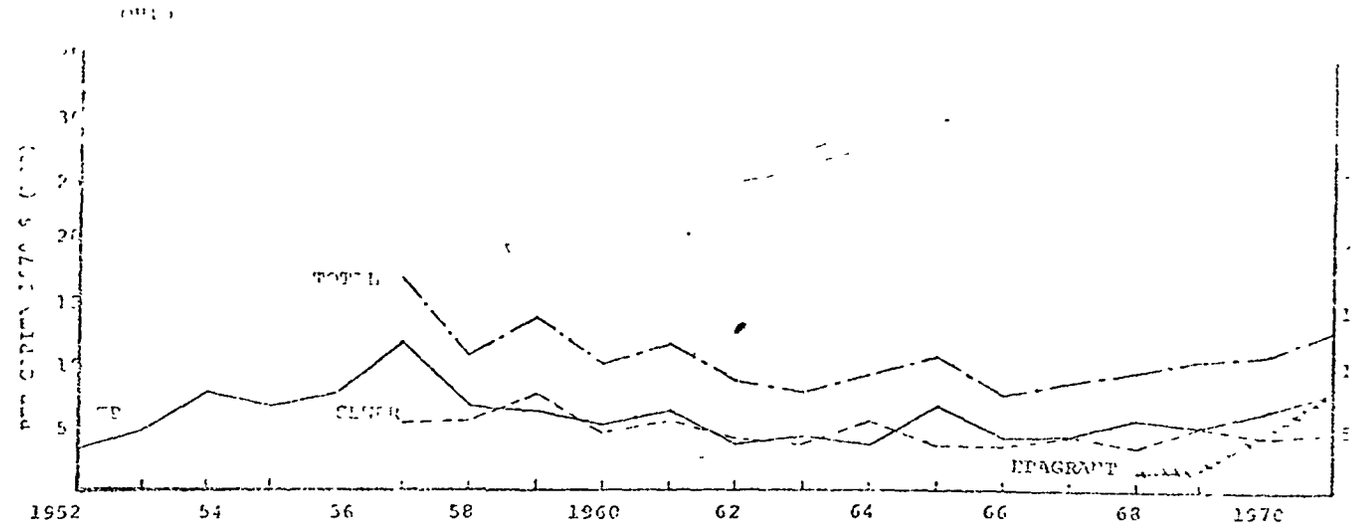
CONSTANT 1970 $ (ENR)

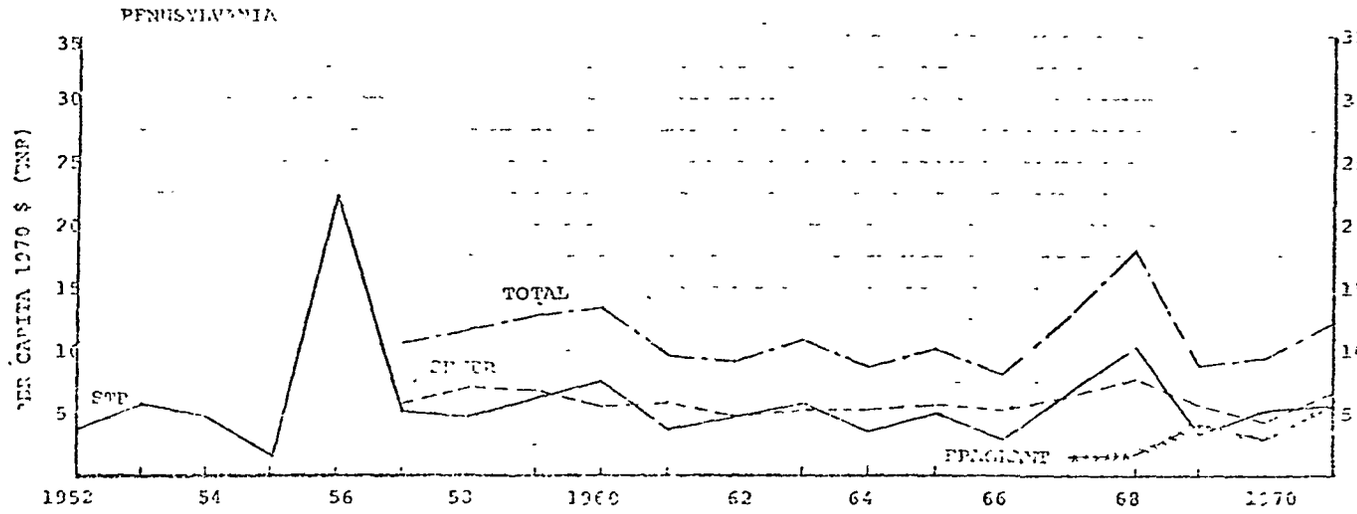


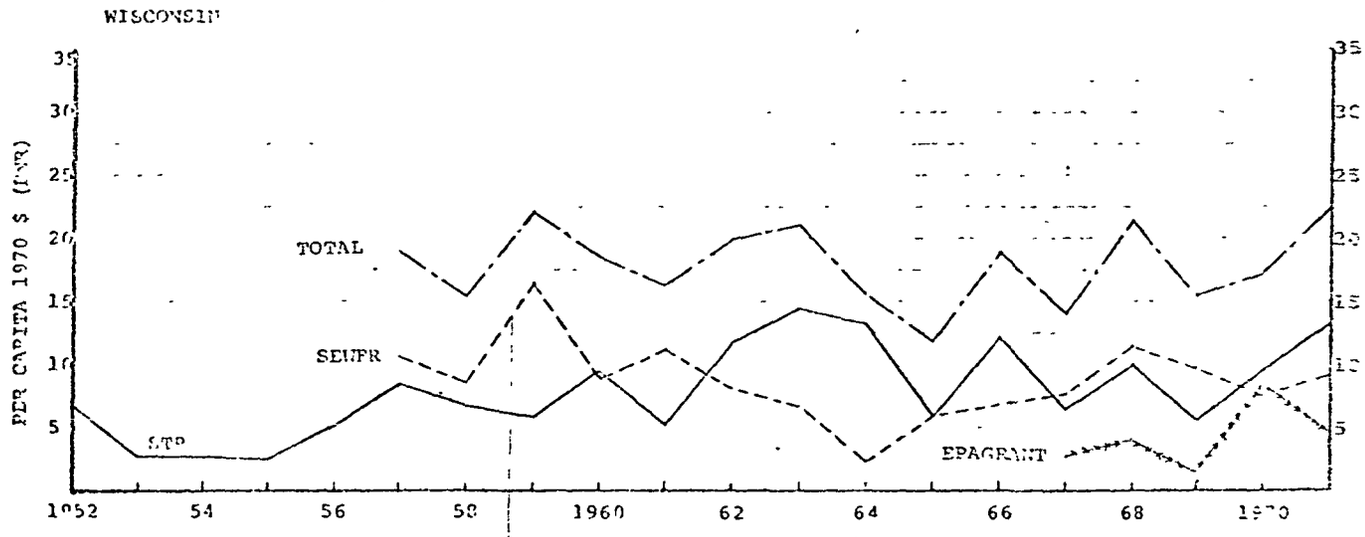








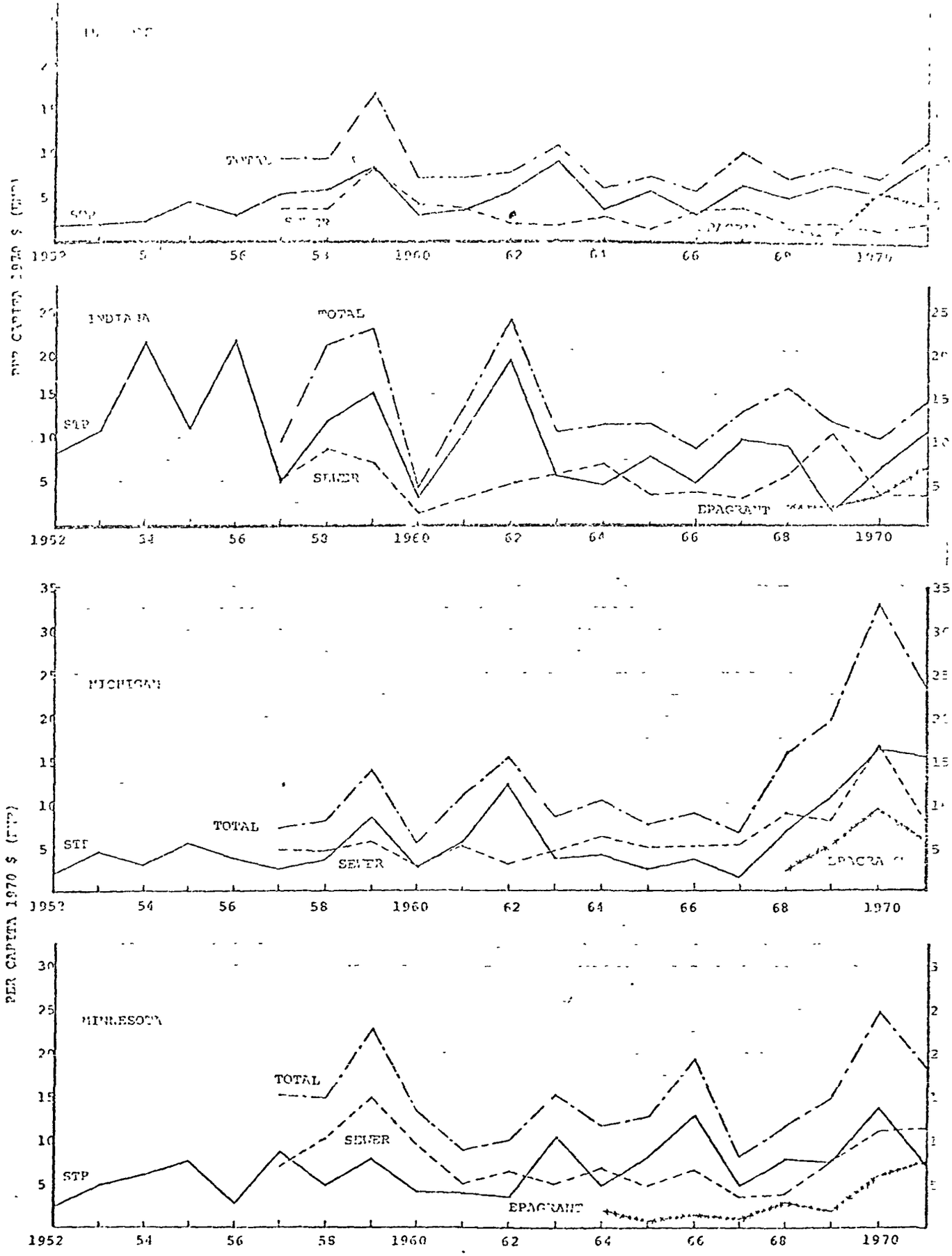




CONTRACT AWARDS (SEWER, STP AND TOTAL) AND
EPA GRANTS ON A PER URBAN CAPITA BASIS.

CONSTANT 1970 $ (PTP)

STP ————
SEWER - - - - -
TOTAL —·— —·—
EPAGRANT ———



STP
SEWER
TOTAL
EPAGRANT

CONTRACT AWARDS (SEWER, STP AND TOTAL) AND EPA GRANTS [illegible] PER URBAN CAPITA BASIS.

CONSTANT 1970 $ (EPR)

IV. CONCLUSIONS

1. State-by-State pollution control achievements do not appear to be related to political strength of local environmentalists, legislative powers, formal administrative structure, extent of conservation program budget size or manpower. There are indications that States with unusually large water quality staffs will have grave difficulties in achieving substantial progress. The only characteristic that serves to correlate with abatement progress is reasonably orderly and documented knowledge of water quality and major dischargers.

2. The Federal water quality program, despite its powers, has not achieved much improvement in State programs, with a notable exception in the setting of water quality standards and some success in emphasizing pollutants other than the perennial BOD and suspended solids. Federal planning and reporting requirements as well as construction grant procedures and delays have probably impeded abatement progress.

3. Federal-State relations are poor, to say the least, and appear to be deteriorating.

4. State progress cannot be evaluated by means of submitted paper; we know of no way of evaluating a State without actually visiting to see what the State is doing and not doing.

5. There appears to be little [illegible] in effectiveness for the [illegible] implementation of effluent standards and water quality standards. Either one can be easily translated to effluent and limit conditions for a permit. The permit is nothing more than a piece of paper until it results in inspection and enforcement.

6. Noncompliant municipalities are especially difficult for the States and EPA to deal with. Sewer bans and 180-day notices do not have the bite of civil injuctions against noncompliant industries. Nevertheless, some States seem to have mastered the art of exacting compliance from reluctant municipalities; more attention should be paid to this art. Wisconsin's secret seems to be a tough bargaining facade and an adamant refusal to grant any extensions, no matter how reasonable the excuse. New York reports that performance bonds have reduced schedule slippages to a minimum.

7. The States and the Federal EPA devote far too much attention to small (or even tiny) dischargers. To make the most of limited resources, it is vital that large dischargers receive more attention than small ones. In this simple matter, none of the States we have reviewed (with the possible exception of Indiana) show much sense of proportion. Major cities such as Detroit, Cleveland, and Milwaukee plainly merit much more attention and money than an

[illegible] residential, trailer camp, or [illegible] filling; industrial [illegible] U.S. [illegible], Kimberly-Cl[illegible] and Standard Oil plants require more action than a small dairy, slaughterhouse, or foundry. Much may be said for putting the small dischargers to one side and dealing with them after the major dischargers have been disposed of. By any rational standard, far too much time and effort are expended on relatively trivial sources of pollution.

8. None of the multi-government, centralized sanitation districts in the Great Lakes Basin showed noticeable success in coping with pollution within their jurisdictions.

V. RECOMMENDATIONS

1. To improve Federal-State relations and use Federal power to accelerate abatement, EPA should conduct an annual on-site evaluation of each State (approximately 2 men for 2 weeks).

This evaluation must focus on results in pollution control: the end product should be a short two page summary of State capabilities with respect to the 7 questions employed to evaluate States. The summary should be used in practice (at the Administrator level and below) as the guiding document for all "diplomatic" relations and major decisions with respect to each State, particularly for construction grants, permit program delegation or revocation and program grants. These monies and powers should be applied specifically to the State weaknesses identified in the summary; under no circumstances should grant formulas be used.

All other EPA contacts with the States should be minimized. EPA is not a monolithic organization; when several of its pluralistic interest groups make direct contact with the States and demand inconsistent and repetitive cooperation from staffs that are already overburdened, annoyance and despair are the predictable results.

2. EPA should ask for only one annual submission from the States covering all reports, applications and plans required under the new Act.

This [illegible] should focus on results, not program [illegible]. We know of no other way to [illegible] discipline on EPA's burdensome paperwork demands on the States.

3. EPA should use every means at its disposal to reduce the burden of paperwork required of the States; it should also urge the States to reduce the paperwork they in turn require of both municipal and industrial dischargers. There is far too much dead paper in filing cabinets, and much of this paper is very costly. Why should a State require dischargers to submit daily effluent reports when it cannot hope to verify them more than once every several years? Valuable manpower and scarce money could be better devoted to such absolute essentials as stream surveys, on-site inspections, properly executed load allocations, and construction of treatment facilities.

4. The States must be encouraged through the new guidelines to streamline their cumbersome procedures for collecting essential data and putting them to work.

To put these data to work, every file on every discharger and body of water must begin with a clear chronological summary of water-quality conditions, applicable standards, effluent loads, enforcement actions, compliance schedules (data due and date done), resultant reduction in effluent load, and consequent change in water quality.

Other information is of [illegible] value to pollution control. A small, [illegible] file of essential information is infinitely more useful than a [illegible] file that is missing some or all of the essentials. As mentioned [illegible], the files must be made short, thorough, and to the point. The Permit Program should be used as a lever to force the States to gather these essential data; it should not be used to complicate paperwork by adding yet another source of unverified information.

5. There is far too much delay and uncertainty in obtaining Federal funding under the State Program Grant and Construction Grant programs. Delays and slippage at the Federal level do not set an example of promptness to the States. Furthermore, Federal delay is the most used excuse for the States' failure to meet compliance schedules. The administration of these funding programs must be made swift, sure, and simple. Delay must not be used as a mechanism for reducing expenditures.

6. Just as we advocate that the delivery of these Federal funds should be swift, sure, and simple, we encourage EPA to deny a substantial percentage of program grants until the States meet certain simple but essential conditions on stream surveillance, effluent monitoring, load allocation, enforcement of compliance schedules, and case preparation. Through its powers of review and its control of the Federal purse, EPA

[illegible] tools [illegible] made to the States' development of more effective, [illegible] control programs.

7. EPA should cease encouraging (and funding) lengthy and complex planning documents, mathematical modeling and extensive computerization. All of these represent impediments to clean-up and divert skilled manpower from essential monitoring, competent inspections, straightforward waste load allocations and vigorous enforcement.

8. Municipal needs surveys, construction priority algorithms, construction grant formulas, etc. should be abrogated. There should be only one basis for construction grant qualification in the next few years: demonstrated violation of local water quality standards and a present discharge in excess of an established waste load allocation for the reach. In terms of both the Act and rational management, no municipal "need" should be accepted unless it meets the above two criteria.

9. Section 208 areawide management authorities and plans should be discouraged, not encouraged. They represent a great potential for delay and offer no discernable economies.

10. The new Permit Program should explicitly state how it intends to deal with and enforce against large users of municipal systems. This should be decided and settled for each State permit delegation and for each municipal permit. Both the States and EPA have actively

[illegible] issue [illegible].

11. [illegible] States [illegible] much [illegible] to [illegible] consistently base waste load allocations on the assumption that non-point sources and upstream loads do not exist. That is, waste load allocations have been calculated by assuming that only known point sources within the study reach can cause a water quality standard violation. Thus, much larger loads can be allocated to each discharger than if non-point contributions were made part of the allocation. This leads to requiring substantial treatment while guaranteeing that standards will not be met (which is probably illegal); it also creates no incentive for non-point source measurement control.

12. Since the States normally avoid monitoring for (or enforcing against) a wide range of toxic substances, EPA should exert strong pressure in guidelines, permits and grants for simple biological tests of effluents for toxicity and serious detection and enforcement effort. The classical pollution control emphasis on BOD and DO that EPA and the States have fostered in the past is misguided, to say the least.

13. As a matter of high priority, a thorough [illegible] for Lake Michigan and Lake Erie before any more money is spent. This a scientifically credible test of the hypothesis that phosphorus stimulates blooms in the lakes is necessary. If the hypothesis is proven, all construction grant money not previously committed should be diverted to phosphorus removal for <u>total city loads</u>, since this is probably a 1-2 order of magnitude cheaper and more effective approach to reversing eutrophication than secondary treatment.

APPENDIX I

The University of Wisconsin

WATER CHEMISTRY LABORATORY
MADISON, WISCONSIN 53706
262-2470
AREA CODE 608

February 14, 1973

DeWitt Johnson
U.S.-EPA-Region V
S & A Division, Technical Services
1 North Wacker Drive
Chicago, Illinois 60606

Dear DeWitt:

As a follow-up to your telephone call last week, I wish to reiterate some of the points made at that time. First, I understand that you are interested in trying to obtain information on current monitoring programs on selected Great Lakes. In this connection, it is my understanding that the work that we are doing on Lake Superior is not within the scope of your study.

I suggest that you contact Nelson Thomas of the EPA Grosse Ile Laboratory. Nelson is the EPA coordinator for the IFYGL studies on Lake Ontario. He should be able to give you a detailed breakdown of these studies. I am involved in several phases of these studies, including work on nutrient transport cycling within Lake Ontario, factors limiting algal growth in Lake Ontario, and work on chlorinated hydrocarbons of the chlorodioxin type.

I suggest that you contact Dr. Beeton of the University of Wisconsin-Milwaukee, Center for Great Lakes Studies. He would be able to inform you about the nature of their studies on Lake Michigan. You should also contact Dr. Sager and also Dr. Wiersma of the University of Wisconsin-Green Bay. Both of these individuals have studies underway which may be of interest to your office. At the University of Michigan, you should contact Dr. Schelske, Dr. Callender, and Dr. Ayers, and at the University of Wisconsin, Madison, Dr. Bowser.

As far as my own work is concerned, I am currently involved in the studies of zinc, TFM (sea lamprey larvicide), silica and phosphorus in Lake Michigan. I can provide additional details on this work, if you wish.

From you description of your activities, it appears that you may be duplicating to some degree some of the work that the Inter-

national Joint Commission is undertaking with respect to the Great Lakes. For example, I have recently been appointed to the Committee on Eutrophication Research for the Great Lakes of the International Joint Commission. This committee consists of three U.S. and three Canadian members, with Dr. Vollenweider of the Canada Centre for Inland Waters as chairman. The Committee is currently undertaking to define what constitutes a proper monitoring program for the eutrophication of the Great Lakes. I suggest that you contact Dr. Vollenweider concerning this situation. He may be able to provide some general guidance as to expected rate of committee development in this area, etc.

One type of monitoring program that is receiving increasing use in the Great Lakes today is the industrial monitoring program associated with thermal electric power plant discharges. I am currently serving as a member of two different industry advisory consultant boards where I advise the industry on the type of program that should be established and on how data should be collected, examined and reported. These types of programs represent very significant sources of data when the data is made available. One of the current studies that I act as a consultant for is spending in excess of $1.7 million per year in one relatively small area of the Lake Michigan shoreline. Another one is spending close to $1 million per year at another part of the Lake Michigan shoreline. I know of studies of similar magnitude being conducted at other power plants on the Great Lakes. Eventually, we will learn a lot about the Great Lakes as a result of these studies, since for the first time we are beginning to approach levels of funding necessary to take on the very complex nearshore environment of the lakes.

The final point that I wish to make in this letter in regard to your activities is that I have felt for some time that the EPA should appoint an informal advisory group to help them establish a monitoring program on the Great Lakes. I would be pleased to work informally with you and Dr. Zeller and others in the EPA in this area.

Sincerely yours,

G. Fred Lee
Professor of Water Chemistry

GFL/ky

APPENDIX J.

GREAT LAKES RESEARCH DIVISION

THE UNIVERSITY OF MICHIGAN
1077 NORTH UNIVERSITY BUILDING
ANN ARBOR, MICHIGAN 48104
313/764-2420

February 22, 1973

Mr. Welburne Dewitt Johnson
Surveillance and Analysis Division
Technical Support Branch
Environmental Protection Agency
One North Wacker Drive
Chicago, IL 60606

Dear Mr. Johnson:

Dr. J. T. Wilson, Director of the Institute of Science and Technology, has asked me to reply to the request expressed on your recent visit to campus for recommendations on monitoring programs in the Great Lakes. Our recommendations will be restricted to monitoring water quality. In general we would recommend that first priority be given to monitoring Lake Michigan for the following reasons. Lake Ontario is being intensively studied as part of the International Field Year on the Great Lakes and it and Lake Erie have been investigated (monitored) by the Canada Centre for Inland Waters in the past several years. On the other hand, no extensive open lake and near-shore monitoring has been conducted on Lake Michigan since the early 1960's. It would seem especially important, considering the present interest in Lake Michigan, that it be given first priority. We need to know whether or not environmental conditions in Lake Michigan are improving or deteriorating. We (Schelske and Stoermer 1971, Science 173, p. 423-424) predicted that environmental quality of Lake Michigan would deteriorate if phosphate inputs were not controlled. We also questioned whether current measures to control phosphorus would be sufficient. Questions such as this can be answered only by instituting monitoring programs on Lake Michigan.

Our recommendation for a minimum monitoring program would be at least two lake-wide cruises in 1973 to monitor the following parameters: total and soluble phosphorus, nitrate nitrogen, and reactive silica. Measurement of these parameters can be justified on a scientific basis, as well as their usefulness in a monitoring program. When one monitors these parameters, it would also be feasible to collect data on ammonia and nitrite nitrogen and on conservative ions including chloride, sulfate, calcium, magnesium, sodium, potassium, alkalinity, conductivity, and pH. Some of these parameters and parameters like dissolved oxygen must be measured on shipboard as soon as possible after sample collection. In the past few years, we have perfected and refined techniques as they pertain to the Great Lakes and presently have the capabilities of doing the monitoring outlined above.

A minimum monitoring program should include as much attention as possible to the biological components of the system, particularly various parameters related to phytoplankton. Phytoplankton, being at the base of the food chain, probably reflect environmental changes more rapidly than other biological

components. In addition, we probably can determine indicator species of pollution with phytoplankton with greater sensitivity than is possible with zooplankton, benthos, or fish.

We would therefore recommend that the following be studied with regard to phytoplankton: abundance and species composition, chlorophyll a, and primary productivity. It would also be desirable to obtain data on species composition and abundance of zooplankton and benthos. Collection of samples could be incorporated with the sampling program needed for monitoring at little if any additional expense. On our large research vessel, we collect samples with different gear, so several sampling activities can be underway simultaneously.

Other than the need for at least two cruises per year, it is almost impossible for a number of reasons to recommend other details about a sampling program. First, the program depends on the amount of money available. Second, costs will vary depending on whether existing facilities are used or whether large amounts of money will be needed for equipment. Third, the sampling network proposed will be a function of the parameters measured which will depend partly on decisions made by the Environmental Protection Agency. Fourth, your need for information by March 1 limits us in working out specific details. Fifth, the March 1 deadline means you hopefully will consider recommendations for sampling in 1973 on projects which can be implemented within a relatively short time.

My final recommendation therefore would be to select, for your 1973 monitoring, only projects which are currently underway on the Great Lakes and can be expanded to meet objectives of the Environmental Protection Agency. During what remains of 1973, plans could be formulated for expanded monitoring programs to be initiated in 1974.

What has been recommended above can be undertaken as lake-wide monitoring. The Great Lakes Research Division has staff members who are well qualified and experienced in all of the areas listed. We could perform the needed monitoring in 1973 from our vessels and provide experienced project directors on a part-time basis for all phases of the scientific work. Funds would be needed to support the project direction and to provide technical assistance in addition to our present staff.

The Great Lakes Research Division and the University of Michigan obviously have many other capabilities that go beyond these recommendations, but these would have to be explored after your March 1 deadline. Professor Baker has additional recommendations about atmospheric monitoring.

Sincerely yours,

Claire L. Schelske

Claire L. Schelske
Research Limnologist

CLS:jf

APPENDIX K

DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE

The University of Michigan
College of Engineering
4072 East Engineering Bldg.
Ann Arbor, Michigan 48104

313/764-3335

February 28, 1973

Welburne DeWitt Johnson
Physical Scientist
Surveillance and Analysis Division
Technical Services Section
U.S. Environmental Protection Agency
Region V
One North Wacker Drive
Chicago, Illinois 60606

Dear Mr. Johnson:

As agreed upon on 16 February, I spoke to several of my colleagues in the Department of Atmospheric and Oceanic Science to find out their research and interest in atmospheric monitoring. Because of the short notice of your request, I did not have time to go outside of our department, although I'm sure much is being done.

The people I spoke with were A. Nelson Dingle, Professor of Meteorology; Donald Stedman, Research Associate in the Institute of Environmental Quality and Lecturer in both our department and the Chemistry department; Conrad Mason, Associate Research Physicist. There was unanimous enthusiasm for the development of monitoring stations, although it was clear that the details of such a network would require a considerable amount of planning to be effective. Both Professor Dingle and Dr. Stedman have been actively involved in trying to establish such a network for environmental reasons and hence were very happy to hear that EPA is moving in this direction. I have tried to outline below the expertise in this area of the four of us. You will notice that this expertise covers a wide range of physical and chemical aspects of the monitoring problem.

Dingle

Professor Dingle's work, mainly under AEC sponsorship, has entailed extensive and intensive field sampling programs designed to measure the amounts of various contaminants brought to the surface by rain. Contaminants studied this way include the important radionuclides produced by nuclear weapons, various metallic elements and plant pollens. This program led to the development of artificial tracer experiments for the investigation of circulational and scavenging models of midwestern summer convection storms, and of the analytical procedures by which metallic indium tracer can be identified and measured in water samples down to 10^{-12} gm cm^{-3} concentration.

In conjunction with, and extension of, the neutron activation analysis techniques and the sampling techniques required for the

above research program, the analytical procedure was adapted to multi-elemental analysis in the extensive air-pollution study of Rahn. ("Sources of Trace Elements in Aerosols--an Approach to Clean Air"; Ph.D. thesis) The gamma-radiation analyzer has been retained as a facility in the Phoenix Memorial Laboratory.

Professor Dingle has most recently undertaken the theoretical modelling of the rain scavenging processes which include nucleation of the condensation of water, diffusion of contaminant particles to water drops and droplets, and impact-collection of particles by falling precipitation. He is moving toward the incorporation of these models with the dynamic models which govern the primary transport of the contaminant material, particularly in convective storm systems.

Stedman

Stedman's speciality is in gaseous atmospheric monitoring, with particular emphasis in developing modern methods for measuring low-level trace gases. He has taught and/or will be teaching three pertinent courses: one in atmospheric chemistry, one in air pollution chemistry and a laboratory in instrumental analysis. He is currently directing a student whose thesis research will be air monitoring using the Wayne County A.P.C.O. equipment. He has set-up bench type NO_x/Ozone monitors in chemistry and a chamber for calibrating gases at low concentrations. He is active in the development of chemiluminescent analysis of NO, NO_2, NH_3, O_3, H_2S, SO_2, and N_2O. His work also includes studies of the role of hydroxyl radicals in the chemical kinetics of photo-chemical smog and ambient air monitoring of the photo-stationary state in photo-chemical smog. He is also involved in a study of the environmental impact of the space shuttle.

Mason

Dr. Mason's research and teaching has been in many diverse areas. He has taught courses in air pollution chemistry, air pollution meteorology, and urban climates. He has had considerable experience with mass spectrometers and has used them to study stack discharges. Presently, he is conducting a feasibility study of a rocket-borne chemiluminescent NO detector. Although this study is for detection of NO in the 30-80 km altitude range, apparently, similar instrumentation would probably be applicable in the lower atmosphere. He is particularly interested in dispersion and modelling of dispersion processes. Along these lines, he is co-author of a paper, "Urban Air Pollution Modelling" that will appear in the Encyclopedia of Environmental Science and Engineering. He is conversant with the dispersal of biological organisms and serves as a consultant to the Aero-biology Program of the International Biological Program.

Moses

Although not resident at the University of Michigan, Dr. Harry Moses of Argonne National Laboratory is an Adjunct Professor with our department. He is very well-known for his studies of air pollution episodes in the Chicago region, and studies of nuclear reactors. Unfortunately, I did not get a chance to talk with Dr. Moses concerning the monitoring program.

Baker

I am currently involved in a determination of the effects on the environment of various nuclear power plant cooling methods. The major "pollutants" in this case are heat and water vapor. A network of 25 meteorological stations around the Cook Nuclear Power Plant and the Palisades Nuclear Power Plant in western Michigan has been established. The network monitors temperature, moisture, rainfall, visibility, radiation and wind. I am also involved in the large scale and mesoscale variations of the atmospheric boundary layer, particularly those effects caused by the Great Lakes. As I am sure you know, it is the mesoscale meteorological variations which are important in air pollution episodes.

The above covers what is being done. Several suggestions, which I think may be of value in your planning, were also given so I thought I would at least mention them.

It was felt by all of us that there should be at least one main monitoring station which incorporates the latest in monitoring equipment and manned by knowledgeable personnel. In this way new equipment could be tested against standard instruments before sent into the field. It was pointed out that a site near Ann Arbor would be a good location since Ann Arbor gets air masses from many different directions: an E wind brings Detroit air over us, a WSW wind gives us Chicago air, a N wind brings clean Canadian air in. Hence, air of many different origins can be sampled at one place. Apparently, according to the work of Rahn, air of each origin is easily recognized from the ratios of its various pollutant levels. A less comprehense network of complementary stations around this main monitoring station was suggested. Such a network would add considerable information on the attenuation and deposition of the air pollution components.

Some details of the monitoring itself were discussed, although not in any detail. Apparently, some components can be measured with

currently available instrumentation. However, for other components new instrumentation like mass spectrometers and chemiluminescent detectors are needed. It was also indicated that a knowledge of the vertical distribution of gaseous and particulate material is very important, although the only methods of obtaining this information put forward was by aircraft soundings and Lidar.

I hope the above information will be of some value to you. Of course, we would all like to be involved in the establishment of the monitoring network. In fact, it is my own personal belief that it would be advisable that a planning study be conducted before any instrumentation is bought. If I can be of any further assistance, please let me know, or any member of our group.

Sincerely yours,

Dennis G. Baker
Assistant Professor
of Meteorology

DGB:bb
cc: E. Epstein, Chairman, Atmospheric and Oceanic Science
A. Nelson Dingle
Donald Stedman
Conrad Mason
D. C. Chandler
C. F. Schelske

APPENDIX L.

UPPER GREAT LAKES WATER QUALITY STUDIES

PRELIMINARY STUDY PLAN

by

IJC UPPER GREAT LAKES REFERENCE GROUP

February, 1973

DRAFT PRELIMINARY STUDY PLAN

IJC UPPER GREAT LAKES REFERENCE GROUP

On April 15, 1972, the United States and Canada signed an Agreement concerning Great Lakes Water Quality which included among other items a Reference to the International Joint Commission to study pollution problems of Lake Huron and Lake Superior.

Subsequently, the Water Quality Board, established by the IJC, instructed the International Upper Lakes Reference Group, also established by the IJC, to provide a preliminary study plan, with a schedule and costs appropriate for the questions posed in the Upper Lakes Reference, namely:

(1) Are the waters of Lake Superior and Lake Huron being polluted on either side of the boundary to an extent (a) which is causing or is likely to cause injury to health or property on the other side of the boundary; or (b) which is causing, or likely to cause, a degradation of existing levels of water quality in these two lakes or in downstream portions of the Great Lakes System?

(2) If the foregoing questions are answered in the affirmative, to what extent, by what causes, and in what localities is such pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what remedial measures would, in its judgement, be most practicable to restore and protect the quality of the waters, and what would be the probable cost?

(4) In the event that the Commission should find that little or no pollution of the character referred to is taking place at the present time, what preventive measures would, in its judgement, be most practicable to ensure that such pollution does not occur in the future and what would be the probable cost?

The date given by the Water Quality Board for submission to it of the final report was December 31, 1975.

This document contains a proposed Study Plan which should be considered as preliminary and subject to intensive review and implementation in the immediate future.

In the brief time available to prepare this Study Plan, the Reference Group has consulted with scientists and engineers within the government bodies which are most likely to participate in the study. From these sources, most of the study proposals and virtually all of the cost

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estimates have been obtained. Some major premises were adopted in the preparation of this Study Plan. First, the Canada-U.S. Agreement makes specific reference to the "non-degradation" of the waters in the Upper Great Lakes. Consequently, it is considered to be highly important to establish baseline levels of concentrations and distributions of materials in each of these lakes. Secondly, the Study Group has strongly recognized that the Upper Great Lakes differ markedly from the Lower Great Lakes in that the more serious existing and potential pollution problems exist in the waters of embayments and the coastal waters adjacent to point sources. For this reason, considerations of each lake merely as a whole would cause the most serious pollution problems to be overlooked.

The Study Plan includes several distinct items of attention. These particular items, and the order in which they appear, are not based solely on the science of the problems being investigated, but rather on the basis of practicalities, such as program management and costing. In many cases, specific proposals by study groups which provide details of these items have been reviewed by the Reference Group. In all cases, the Reference Group has identified a costing source and potential study participants.

I Background Information on the Basin and its Population

The proposed water quality study of the Upper Lakes will require preparation of background summaries of the characteristics of basin and atmospheric properties which are influential. This broadly includes: basin geology, hydrology, climate, population characteristics, land use and development, and water uses.

Although much of this requirement is straight-forward, physical and social scientists involved in various aspects of this Study defined later should provide certain specific summary requirements.

This aspect of the Study should be undertaken in conjunction with the same task of the Land Drainage Reference Group.

II Surveys of the Main Bodies of the Upper Lakes

In order to enable assessment to be made of the existence and movements of pollutants in the main bodies of Lake Huron and Lake Superior, and to provide bases for non-degradation criteria, collections of chemical, physical, biological and geological data are recommended.

A broad range of chemical data is required, similar to that collected for the Lower Lakes in the previous IJC study, but with increased emphasis on pesticides, PCBs, mercury and phenols, especially near the coastal regions. Data on the sediments are needed to ascertain the existence and pathways of certain

....3/

II Surveys of the Main Bodies of the Upper Lakes (cont'd)

pollutants (e.g. mercury), and the history of pollution occurrence. Temperature data are needed in order to evaluate the role of thermal structure in the occurrence and movements of pollutants in various parts of the lakes, and those limnological processes which encourage productivity.

Biological and microbiological data for the lower stages of production are needed to assess trophic levels, influences of pollutants on populations, pollution pathways, and the occurrence and nature of bacteria populations. Information on fish populations and the occurrence of pollutants in fish is also required but has not yet been introduced into the Study Plan.

Excluding the fisheries aspects, data of the above types have been recently collected in all lakes by the Department of the Environment, Canada. A variety of data also exists from previous years, collected by several U.S. and Canadian agencies. These collections are almost adequate for Lake Huron, except in the case of certain items (Hg, PCB, pesticides, phenols) which should be sampled, especially in the coastal regions. Considerable additional sampling of all types is needed for Lake Superior and Georgian Bay, and for both lakes in winter months.

Accordingly, it is recommended that the following "main lake" surveys be done:

1. 6 or 7 surveys of Lake Superior; physical, chemical and biological (P, C, B) during 1973.

2. 4 surveys of Georgian Bay (P, C, B) during 1974.

3. 2 winter surveys (P, C, B) of Lake Superior and two of Lake Huron, winter of 1973-1974.

4. 2 "special" surveys of Lake Huron during 1974 to collect data itemised above, at about 20 stations, emphasizing nearshore regions.

5. A geological survey of the sediments of Lake Superior, during 1973.

In order to provide information on the transboundary movements of pollutants, a review of past current meter data and a study of a data collection of the U.S. Environmental Protection Agency will be included. Further studies during 1974 would be proposed, if needed. Two proposed additional circulation studies, one in western Lake Superior and one in southern Lake Huron, to examine transboundary movements in regions of known interest are proposed by DOE,

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II Surveys of the Main Bodies of the Upper Lakes (cont'd)

Canada and should be considered. These are not included in the cost summary.

Thermal and water colour surveys using remote sensing techniques from aircraft and satellites are recommended, both to obtain basic data and to evaluate possible uses of these techniques for surveillance.

III Sources and Characteristics of Material Inputs

In order to determine the net effects of materials inputs to lakes, materials budgets should be calculated. The loadings of materials from municipalities, industries and tributaries should be monitored more intensively and with a high degree of accuracy. A list of recommended items for tributary inputs is included in Appendix A. This list should be applied at least once for each municipal and industrial discharge direct to the lakes. The atmosphere as a source of materials will also be included in the study.

Movement of materials between lakes is an important materials budget consideration. Particular attention should be paid to interlake transport between Lake Michigan and Lake Huron, and between Georgian Bay and Lake Huron. Studies on the former are proposed by the U.S. Lake Survey and on the latter by DOE, Canada.

A close working relationship must be developed with the implementation of the Land Drainage Reference Group studies, in order to enable the Upper Lakes study to benefit from those studies in determinations of the nature and quantities of inputs from land drainage.

IV Geographic and Water Resources Relationships

Materials budget data collections such as outlined above, will hopefully be sufficient to determine an assessment of present conditions of loading to and deterioration of the Upper Great Lakes. In order to realistically assess future problems and permit recommendations on programs to alleviate anticipated problems, assessments of trends in conditions which cause pollution problems must be made. These will include studies of the interrelationships between population, water uses, and the effects of these upon materials inputs to the lakes. Studies on the future trends which will influence these interrelationships are considered to be an important part of this study. The influences of human and other activities on the land drainage influences on these lakes will be provided in consultation with the Land Drainage Reference Group.

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V Coastal and Local Effects Studies

The Reference Group has recognized that high priority must be given to the coastal regions of the Upper Lakes as the majority of presently identifiable water quality problems exist in the bay, and coastal waters adjacent to sources of inputs. Consequently, studies in coastal regions are required to identify the occurrence and extent of water quality impairment and delineate the sources contributing to this impairment in order to determine what and where remedial and preventative measures should be taken for the protection of the local and lake wide quality. Environmental response studies at major waste sources will define their zone of influence and provide the basis for establishment of limits on "mixing zones" and "localized areas" as required by the Agreement.

A major program for studies of this nature on Ontario nearshore waters of lakes Huron and Superior and in the St. Marys River has been proposed by the Ontario Ministry of the Environment. Specific studies are planned by the Province for the examination of the impact of major waste sources at some twelve locations in the Upper Lakes.

Specific studies at point source locations have also been proposed by each of the States of Michigan and Wisconsin. In addition, the federal U.S. Environmental Protection Agency is sponsoring and proposes to undertake studies in embayments containing known pollution problems. The Department of the Environment, Canada, has proposed a "process" oriented study, which would be undertaken at a known problem source but which would be directed towards improving the understanding of the differing ways specific pollutants enter, mix with and affect the lake system, so that the Study directors can better assess future trends in degradation and better define criteria for mixing zones and localised areas.

The Reference Group has been advised that, in the case of the Reserve Mining operations case, which has received considerable public attention, sufficient data has been acquired for the purposes of this Study.

Included in the costs shown later, for this study item, are those related to studies of transboundary movements of pollutants in the St. Marys River region.

VI Main Lake Effects Studies

Section II defined the data collection program which would permit scientific and engineering analyses of the concentrations and distributions of pollutants in the main bodies of the two Upper Great Lakes. This section (VI) is meant to define the interpretations of those data which are considered to be necessary to meet the objectives of the Upper Lakes Reference.

....6/

Appropriate scientists should be designated to examine and interpret the limnological, meteorological and related data which will be collected for this study and indeed participate in the detailed criteria for the data collection, and requested to provide information on baseline concentrations of pollutants, assessments of lake conditions and processes which cause or influence pollution problems, and provide recommendations for abatement and other action which would serve to eliminate existing problems and ensure future non-degradation. Attempts should be made to interpret distributions of properties and data of currents in terms of trans-boundary movement of pollutants, in a realistic manner.

Other Items

The Upper Lakes study report should include a resume of remedial measures available and recommended which would influence the effects of existing and predicted quantities of pollutants. At some time during the Study, the Reference Group may wish to recommend commencement of research and development of remedial measures to meet particular identified needs.

Studies on public perception and attitude are considered to be of value in connection with the overall assessment of public involvement in pollution-problem identification and abatement programs. However, such studies are not deemed to be within the terms of reference of this Group. Similarly, although studies on institutional arrangements have been conducted by the Great Lakes Basin Commission and others are planned by Department of the Environment, Canada, these are also not included as part of this Study Plan.

Appendix B contains a detailed breakdown of costs per fiscal year, with reference to the most probable federal, state or provincial participant.

Recommendations

1. It is recommended that the Water Quality Board act immediately to approve, and establish a procedure for implementing, this Study Plan. As this is a preliminary plan, broad tasks must be assigned to groups of experts for detailed design criteria.

2. The Water Quality Board and the IJC should conduct a review of the membership of the Upper Lakes Reference Group, in consideration of the role it should play in the implementation of the Study Plan. In particular, strengthening in the realm of scientific expertise in water quality - fisheries aspects should be considered.

3. The successful accomplishment of this study will depend upon timely and adequate funding. It is recommended that the Board seek the assistance of the IJC in drawing this fact to the attention of appropriate agencies.

Appendix B: Preliminary Upper Great Lakes Study Plan

SCHEDULES AND COSTS

		1972/73		1973/74		1974/75		1975/76		CALENDAR TI STUDY DURAT FISCAL TIME
	Study Item	MY	$(K)	MY	$(K)	MY	$(K)	MY	$(K)	Source
I	Background information: hydrology, climate, geology, population, land use, water use			.4	8				2	Canada
				.5	12					U.S.A.
					2				1	Ontario
II	Main-Lake surveys									
	- Lake Superior (B,C,P)		100		100					U.S.A.
				40	660	4	60			Canada
	- Lake Superior (Geology)			7	140	2.5	50			Canada
	- Winter, Huron & Superior				90					U.S.A.
	- Lake Huron, special surveys						50			U.S.A.
						6	80			Canada
							50			U.S.A.
	- Georgian Bay surveys					12	135			Canada
	- Remote Sensing			1	22	1	35			Canada
II	Sources and characteristics of material input.									
	- direct discharges		75		75		15			U.S.A.
					200		167		65	Ontario
					23		23		12	Michigan
					18		13		9	Wisconsin
					25		25		13	Minnesota
	- atmospheric loading			1	30	1	30	.5	15	Canada

	1972/73		1973/74		1974/75		1975/76		
	MY	$	MY	$	MY	$	MY	$	
- interlake transport (Michigan-Huron)		121		219		30			U.S.A.
				50					Canada
(Huron-Georgian Bay)					3.5	58			Canada
Relationships between, & trends in, geographic & water resources characteristics.					.5	12			U.S.A.
			2	30	3	42	.5	5	Canada
				6.5		6.5		8	Ontario
Local effects (pt. Source Study)				696		510		230	* Ontario
			7	125	14	260	4	52	Canada
		283		450		145			U.S.A.
Whole-lake effects, materials balance, and other interpretations of item 2 data			21	323	21.5	310	9	120	Canada
			3	75	3	75	2	50	U.S.A.
- transboundary movements		20		81		47			U.S.A.
Peripheral costs for engineering, computers, drafting	.5	20	2	50	2	50	1	25	U.S.A.
			7.5	250	8	375	1.5	67	Canada
								28	Ontario
Report writing					1	25	1	35	U.S.A.
					1	25	1.5	50	Canada
TOTALS	.5	619	5.5	1152	6.5	499	4	110	U.S.A.
			88.9	1638	77.5	1460	17.0	309	Canada
				904.5		683.5		332	Ontario
				23		23		12	Michigan
				18		18		9	Wisconsin
				25		25		13	Minnesota

except for Canada, man-year estimates are incomplete (unavailable or irrelevant).

Item #9 costs included

ote: Costs are estimates, provision of funds is subject to funding processes

Preliminary Upper Great Lakes Study Plan – Cost Estimate

Study Period, calendar time	1973		1974		1975			
Fiscal Years	FY 73		FY 74		FY 75		FY 76	
	MY	$1000	MY	$1000	MY	$1000	MY	$10
I Background information: hydrology, climate, geology, population, landuse, water use								
EPA			0.5	12				
II Main-lake surveys:								
Lake Superior (B,C,P)								
EPA		100		100				
Lake Huron, special surveys								
EPA						50		
Georgian Bay surveys								
EPA						50		
L. Superior + Huron winter surveys								
EPA			2	40				
U.S. Coast Guard (vessel)				50				
III Sources and characteristics of material input								
Direct discharge								
EPA (state support)		75		75		15		—
Michigan				23		23		12
Minnesota				25		25		13
Wisconsin				18		18		9
Interlake transport (L. Michigan-Huron)								
EPA Region V		25		43		6		
EPA Grosse Ile		65		50		—		
NOAA		36		126		24		

Study period, calendar time	1973		1974		1975			
Fiscal Years	FY73		FY74		FY75		FY76	
	MY	$1000	MY	$1000	MY	$1000	MY	$1000
IV Relationships, trends, geographic and water resources characteristics								
EPA					0.5	12		
V Local effects, point source studies								
EPA (contracts) Region V								
Duluth-Superior		40						
Saginaw Bay		75						
Green Bay-Tusculum		100						
EPA support to;								
Michigan				25		40		
Wisconsin				25		30		
EPA, Grosse Ile								
Saginaw Bay		68		400		25		
VI Whole-lake effects, material balance, interpretations of Item II data								
EPA			3	75	3	75	2	50
Transboundary movements								
EPA (contract)								
Reduction of L. Superior data		20		30				
Analysis of L. Superior + Huron data								
EPA		—		20		18		
NOAA		—		31		29		

	1973		1974		1975			
	FY73		FY74		FY75		FY76	
	MY	$1000	MY	$1000	MY	$1000	MY	$1000
VII Peripheral costs for engineering computer, drafting								
EPA	0.5	20	2	50	2	50	1	2
VIII Report preparation and publication								
EPA					1	25	1	3
Sub-totals								
EPA Region V								
Upper Lakes Study		290		495		371		1
Enforcement Studies		215						
EPA Grosse Ile		133		450		75		
States				66		66		34
NOAA		36		157		53		
USCG				510				
Totals		624		1,219		565		144

INTERSTATE ELECTRONICS CORPORATION
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OCEANICS DIVISION
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TED ACHREM
Research Analyst

714-772-2811

INTERSTATE ELECTRONICS CORPORATION
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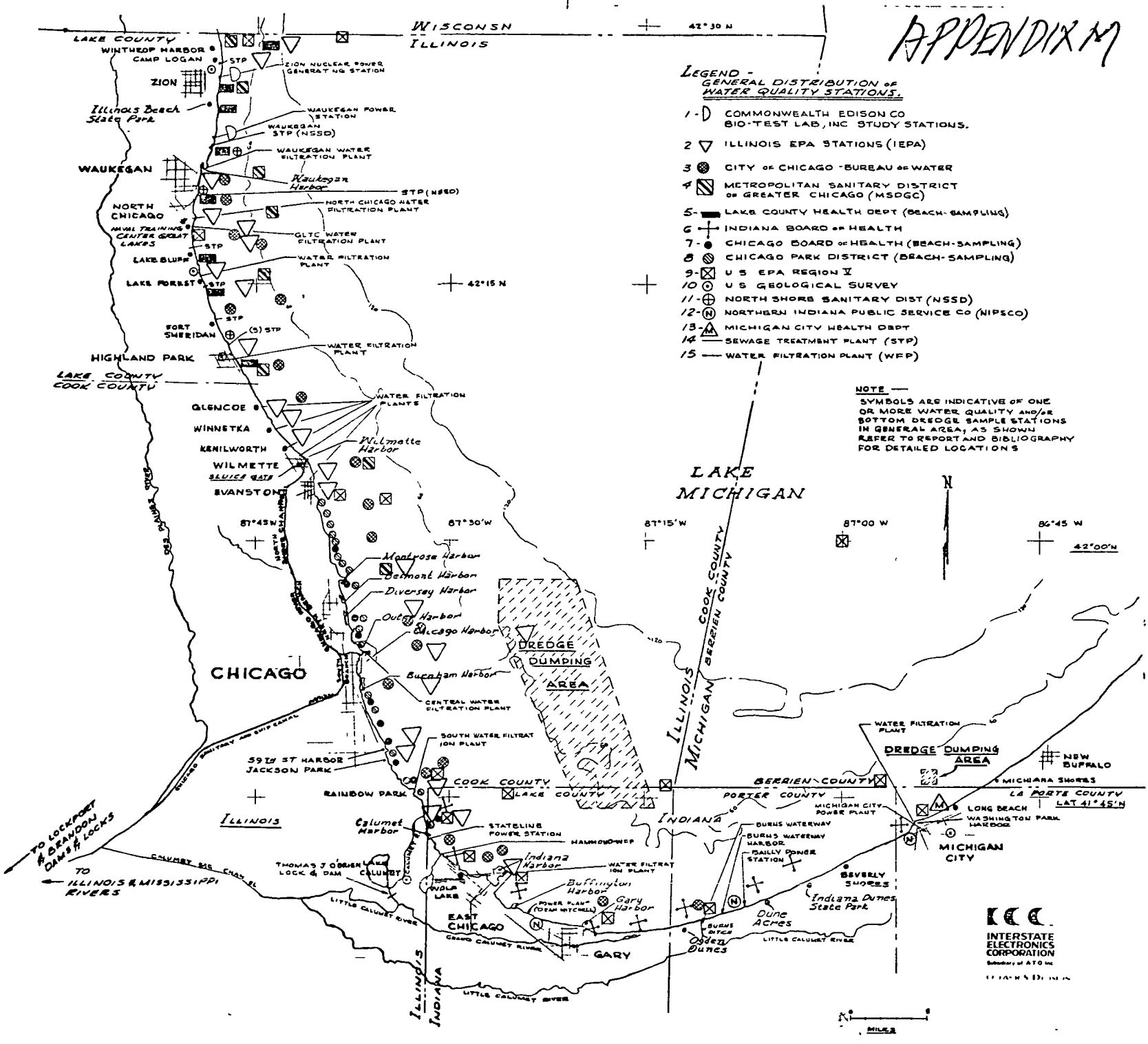
OCEANICS DIVISION
707 E Vermont Avenue
Post Office Box 3117
Anaheim, Calif 92803

WILLIAM B. MERSELIS
Staff Oceanographer

714-772-2811

APPENDIX M



LEGEND - GENERAL DISTRIBUTION OF WATER QUALITY STATIONS.

1 - COMMONWEALTH EDISON CO BIO-TEST LAB, INC STUDY STATIONS.
2 - ILLINOIS EPA STATIONS (IEPA)
3 - CITY OF CHICAGO - BUREAU OF WATER
4 - METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO (MSDGC)
5 - LAKE COUNTY HEALTH DEPT (BEACH-SAMPLING)
6 - INDIANA BOARD OF HEALTH
7 - CHICAGO BOARD OF HEALTH (BEACH-SAMPLING)
8 - CHICAGO PARK DISTRICT (BEACH-SAMPLING)
9 - U S EPA REGION V
10 - U S GEOLOGICAL SURVEY
11 - NORTH SHORE SANITARY DIST (NSSD)
12 - NORTHERN INDIANA PUBLIC SERVICE CO (NIPSCO)
13 - MICHIGAN CITY HEALTH DEPT
14 - SEWAGE TREATMENT PLANT (STP)
15 - WATER FILTRATION PLANT (WFP)

NOTE — SYMBOLS ARE INDICATIVE OF ONE OR MORE WATER QUALITY AND/OR BOTTOM DREDGE SAMPLE STATIONS IN GENERAL AREA; AS SHOWN REFER TO REPORT AND BIBLIOGRAPHY FOR DETAILED LOCATIONS

FIG 2-1

CHICAGO CASE STUDY MONITORING ACTIVITIES

PRELIMINARY

REF: IEC 445-B7 REPORT

~~U. Wis - Milwaukee~~ ~~APPENDIX N~~

February 15, 1973

Dear Mr. Johnson:

Please excuse this hand written note, but all of our secretaries are ill today. I have included the cover letter that Mr. Ashrem of Interstate Electronics Corp. sent Dr. Beeton, with his address and phone on it. I have also included the Xeroxs of the current projects under way here at the Center for Great Lakes Studies. All other Sea Grant projects may be obtained from Dr. Kagatzskie.

I will not be able to send you the address list of water intakes on the Great Lakes. We are under contract with NOAA to do this work, which will be published at a future date.

Sincerely,

Jan W. Strand
Research Assistant

INTERSTATE
ELECTRONICS
CORPORATION
Subsidiary of A-T-O Inc

OCEANICS DIVISION

December 5, 1972

Dear Dr. Beeton:

You have been recommended to us as an informed source on water quality monitoring activity in your area. We are under contract to the Environmental Protection Agency to develop a plan for a "National Coastal Water Quality Monitoring Network Using Existing Capabilities." Enclosure (1) is a letter from the EPA requesting your help in providing information necessary to design the plan.

After conducting a national overview of monitoring activites and general capabilities, we are now obtaining detailed information in the areas of water sampling, laboratory analyses, data management, and program administration. Enclosure (2) illustrates the type of information we desire. You probably have much of this information available in the form of research and annual reports, maps, organization charts, enabling legislation or charter, personnel directories, etc. In addition, we welcome your plans and opinions on potential monitoring improvements or the priorities for a program expansion.

Thank you for your help and cooperation without which we will be unable to properly complete this important task. Should you have any questions, please feel free to call Mr. Ted Achrem, or contact Mr. William B. Merselis, Project Manager, OceanicS Division.

Very truly yours,

INTERSTATE ELECTRONICS CORPORATION

T. J. Achrem

T. J. Achrem
Research Analyst
Ext. 1564

TJA:rjm

Enclosures

707 East Vermont Avenue, Post Office Box 3117, Anaheim, California 92803 Telephone 714-772-2811

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Lake Survey Center
630 Federal Bldg & U. S. Courthouse
Detroit, Michigan 48226

CLSX13

Dear Sir:

The Lake Survey Center is preparing the 1973 edition of the U. S. Great Lakes Projects Forecast Directory. Two separate compatible volumes will be published again in 1973. The Canadian Committee on Oceanography will publish its Directory in a separate volume from ours.

The attached guide outlines the purpose and use of the project forecasts. We ask your assistance in promoting voluntary contributions among your colleagues.

Please return all completed project forecasts for 1973 by February 19, 1973.

Sincerely,

Louis X. Barbalas

Louis X. Barbalas
Chief, Library Section

Enclosures

LAKE SURVEY CENTER, LIBRARY SECTION

GUIDE

Forecasted Great Lakes Oceanographic Projects, 1973

PURPOSE

Many agencies and institutions in the United States and Canada perform Great Lakes oceanographic investigation. This activity requires considerable funds, personnel and equipment.

The current information from these forecasts will allow investigators to coordinate planned projects and avoid duplication of programs and data collection. The directory can also serve as a catalog to answer information requests.

SCOPE

Projects should include scientific research for new knowledge, explorations (e.g., seismic), monitors and surveys (e.g., oceanographic, hydrographic, fisheries), new engineering developments (e.g., instruments, equipment, procedure), and technical services (e.g., hydrographic surveying, data processing and forecasting of waves, fisheries, etc.).

A project is a coherent unit of the program of an agency or institution. It is directed to a definable objective, and the data and/or results shall or can be combined when reporting.

Usually a project is managed locally by one person, e.g., the scientist-in-charge, who is responsible for its completion. Several agencies, disciplines, and locations may be involved.

MATERIAL PROVIDED

1. Two 1973 project forecasts. Additional forecasts will be provided on request, or can be prepared by Xerox or similar reproductive technique.

2. Guide for completing forecasts.

INSTRUCTIONS

Descriptions should be completed in space provided. "Agency" means the agency responsible for the project. It is desirable to consolidate project forecasts that have similar summaries, but noting the various locations. If additional space is required, please continue on a second sheet.

The forecast period is January 1, 1973 - December 31, 1973.

A new or nearly new typewriter ribbon should be used before typing. Type one copy suitable for reproduction on one side of the paper only. Mail the flat (not folded) copy in the enclosed self-addressed envelope. Mail no later than February 19, 1973.

For additional information, please contact Mr. Louis X. Barbalas, Area Code 313, 226-6295.

APPENDIX N

O.M.B. FORM 41-B2685

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Lake Survey Center
630 Federal Bldg & U. S. Courthouse
Detroit, Michigan 48226

GREAT LAKES OCEANOGRAPHIC PROJECT FORECAST 1973

The following information is requested:

1. Project Name: Microbial Degradation of TFM (3-TRIFLUROMETHYL-4 NITROPHENOL

2. Locations(s): Milwaukee Harbor, Milwaukee, Wisconsin

3. Agency: Center for Great Lakes Studies, Univ. Wisconsin--Milwaukee

4. Principle Cooperating Agencies: U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sports Fisheries and Wildlife.

5. Date: FROM: 1 January 1973 (day, month, year) TO: 31 December 1973 (day, month, year)

6. Effort (in man years)

Professional 1/3 Support Services 1

7. Summary: Purpose, theory, procedures, data collection, season(s), major facility or vehicle, special equipment, etc.

Objectives are to determine the rates of decomposition of TFM by microbes present in river sediment and to identify the intermediate compounds formed during this process, to extend the incubation time of the anerobic incubation systems to determine if the primary metabolite (RTFM) or TFM is further degraded. To develop methods for the qualitative and quantitative estimation of TFM melabolites in aqueous systems. Experiments are carried out in the Center's environmental chamber using river water sediment systems innoculated with C-14 labeled TFM and maintained in the dark at 15 ± 3°C.

8. Scientist(s) in charge: Dr. A. M. Beeton and Dr. John Lech.

O.M.B. FORM 41-B2685

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Lake Survey Center
630 Federal Bldg & U. S. Courthouse
Detroit, Michigan 48226

GREAT LAKES OCEANOGRAPHIC PROJECT FORECAST 1973

The following information is requested:

1. Project Name: Project to Determine the Consequences to the Biota of Lake Michigan of Chlorinating a Large Municipal Effluent and Possible Corrective Measures.

2. Locations(s): Milwaukee Harbor Area, Milwaukee, Wisconsin

3. Agency: Center for Great Lakes Studies, Univ. Wisconsin--Milwaukee

4. Principle Cooperating Agencies: Environmental Protection Agency

5. Date: FROM: 1 January 1973 (day, month, year) TO: 31 December 1973 (day, month, year)

6. Effort (in man years)

Professional 2 1/2 Support Services 2

7. Summary: Purpose, theory, procedures, data collection, season(s), major facility or vehicle, special equipment, etc.

Purpose is to determine the effect of chlorination of a large municipal effluent on the biota of a large lake; the effects on major species comprising the benthos and plankton populations of Milwaukee Harbor and adjacent Lake Michigan and whether the effects on the above organisms is due to biocidal action of chlorine or from chloramine compounds resulting from the combining of chlorine with nitrogen compounds in the sewage. To determine what additional chemical treatment could be used to eliminate or reduce the toxicity of chloramines in the sewage and the effects, if any, of such additional treatment to the biota.

8. Scientist(s) in charge: Dr. A. M. Beeton and Dr. Peter Kovacic

O.M.B. FORM 41-B2685

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Lake Survey Center
630 Federal Bldg & U. S. Courthouse
Detroit, Michigan 48226

GREAT LAKES OCEANOGRAPHIC PROJECT FORECAST 1973

The following information is requested:

1. Project Name: Investigation of the Influence of Thermal Discharge From a Large Electric Power Station on the Biology and Nearshore Circulation of Lake Michiga

2. Locations(s): Oak Creek Power Plant, Oak Creek, Wiscons in

3. Agency: Center for Great Lakes Studies, Univ. Wisconsin--Milwaukee

4. Principle Cooperating Agencies: U.S. Atomic Energy Commission, and Wisconsin Electric Power Company.

5. Date: FROM: 1 January 1973 (day, month, year) TO: 1 August 1973 (day, month, year)

6. Effort (in man years)

Professional 1 Support Services 3

7. Summary: Purpose, theory, procedures, data collection, season(s), major facility or vehicle, special equipment, etc.

Through combined study of the ecology of natural populations and the physics of nearshore circulation, the main objective of this project is to assess the influence on Lake Michigan of a large thermal source which has been in operation for many years.

Biologists are investigating the spatial distribution, temporal fluctuations, and persistence of inshore/offshore differences in species composition, nutrition, and biological production. particularly during anticipated periods of coastal entrapment of water masses. Physicists are investigating by means of research cruises and continuous in-lake recordings, those features of the little-understood nearshore circulation which control dispersal of heat and materials and the distribution and production of living forms.

This direct approach, using a full-scale in-lake model, followed by interpretation of the findings (with those of other studies), is designed to provide a reliable basis for enlightened management of power generation in the Great Lakes region.

8. Scientist(s) in charge: Dr. C. H. Mortimer and Dr. A. M. Beeton.

O.M.B. FORM 41-B2685

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Lake Survey Center
630 Federal Bldg & U. S. Courthouse
Detroit, Michigan 48226

GREAT LAKES OCEANOGRAPHIC PROJECT FORECAST 1973

The following information is requested:

1. Project Name: Lake Ontario Temperature Transects Continuously Repeated

2. Locations(s): Transects from Braddock Point, New York to Presqu'ile, Ontario and from Oswego, New York to Prince Edward Point, Ontario.

3. Agency: Center for Great Lakes Studies-University of Wisconsin-Milwaukee

4. Principle Cooperating Agencies: NOAA (IFYGL Program)

5. Date: FROM: 1 January 1973 (day, month, year) TO: 31 December 1973 (day, month, year)

6. Effort (in man years)

Professional 1 Support Services 2

7. Summary: Purpose, theory, procedures, data collection, season(s), major facility or vehicle, special equipment, etc.

As a contribution to the IFYGL Program on Lake Ontario 1972, the investigators are responsible for the measurements and preliminary analysis of variations in temperature distribution in the two Lake Ontario cross-sections as measured from NOAA vessels the RESEARCHER and ADVANCE II on continuous shuttle operations during the periods 24-28 July, 7-11 August and 2-6 October. Measurements were made by use of the Center's developed undulating depth temperature profiler from the RESEARCHER and MBT's from the ADVANCE II. The data collected is currently being tabulated and analyzed for the purpose of contributing to the understanding of the structure and mode of generation of upwelling and dominant internal wave patterns.

8. Scientist(s) in charge: Dr. Clifford H. Mortimer

D7 cofj

IDENTIFICATION AND EVALUATION OF SOURCES OF HYDROGRAPHIC DATA ON THE GREAT LAKES (R/WQ-5)

Principal Investigator: Alfred Beeton, Center for Great Lakes Studies, UWMKE

BACKGROUND

Long term records of environmental conditions are basic to sound ecological studies. The need for such data is critical for study of the Great Lakes because of the accelerated eutrophication which Lake Erie has undergone, and because of similar changes which have occurred in Lake Ontario, Saginaw Bay, Lake Huron (Beeton 1969), and Green Bay, Lake Michigan (Howmiller and Beeton 1971). It has only been recently that any year to year open-lake sampling has been conducted and such sampling varies in extent of area covered, quantity and quality of the observations, accessibility of data, and usually it is not year round. In the past open lake sampling has consisted of a few surveys such as those in Lake Superior by the U. S. Army in 1871, the cooperative studies of Lake Erie in the late 1920's, the Bureau of Fisheries study of Lake Michigan in 1932-33, and the surveys of several areas of the Great Lakes by the U. S. Bureau of Commercial Fisheries, Great Lakes Institute of the University of Toronto, U. S. Lake Survey and University of Michigan during the 1950's, (Beeton and Chandler 1963). Except for a few winter observations, these surveys were conducted during the warmer months. Thus there is need for year round observations as well as long term records.

The U. S. Fish and Wildlife Service recognized that considerable limnological and meteorological data for the Great Lakes should be available from various agencies in Canada and the United States and negotiated a contract with the Great Lakes Research Institute, University of Michigan, to undertake a study of the availability, reliability, and extent of such data. The study was to consist of three phases: 1) location and determination of extent of records, 2) a pilot study in a selected section of the Great Lakes (south shore of Lake Erie) to determine the reliability and usefulness of the various records, and 3) accumulation of those records shown to be useful by Phase II and recording them in a form suitable for easy reference and use. Phases 1. and 2 were completed. In Phase 1 a total of 1177 data sources were identified (Powers, Jones, Ayers 1959). Phase 2 studies demonstrated that certain water intakes were representative of open-lake conditions of Lake Erie whereas others were greatly influenced by local conditions. Phase 3 was not undertaken. The objectives of Phase 2 were only accomplished in part in that the usefulness and representativeness of data from a few intakes were demonstrated but the reliability of the data was not dealt with adequately. The results of these investigations were then published in a report, "Sources of Hydrographic and Meteorological Data on the Great Lakes."

APPENDIX -O

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Eastern Region
633 West Wisconsin Avenue, Milwaukee, Wisconsin 53203

2500
February 12, 1973

Mr. Ron Mustard
Environmental Protection Agency
1 North Wacker Drive
Chicago, Illinois 60606

Dear Mr. Mustard:

In response to your telephone request of February 8, the U.S. Forest Service operates only three water quality sampling stations in the Great Lakes proper.

Lake Superior

Black River Harbor at confluence of Black River and Lake Superior, 15 miles north of Bessemer, Michigan. Periodic surface grab samples take twice yearly since 10/10/72. Analysis for Turb., Temp., pH, Hardness, DO, Alkalinity, Free CO_2, Specific Cond., Color, Cl, PO_4, SO_4, Total-N, Ca, Mg, Fe, K, Na, Si, and Fecal Coliform. Data used to measure impact of upstream campgrounds on water quality. Data appears in Forest reports and available from Ottawa National Forest, Ironwood, Michigan, and EPA STORET system.

Lake Michigan

Lake Michigan Campground, 1 mile southwest of Brevoort Lake and 15 miles northeast St. Ignace, Michigan. Periodic surface grab samples, twice monthly May thru September since 1970. Analysis for Total and Fecal Coliform. Data used to monitor swimming water public health safety. Data appear in Forest reports and available from Hiawatha National Forest, Escanaba, Michigan.

Lake Michigan Recreation Area at confluence of Porter Creek and Lake Michigan, 10 miles north of Ludington, Michigan. Periodic surface grab samples take twice monthly May thru September since 1967. Analysis for Total and Fecal Coliform. Data used to monitor swimming water public health safety. Data appear in Forest reports and available from Huron-Manistee National Forest, Cadillac, Michigan.

Besides those 3 water quality stations in the Great Lakes proper, the Forest Service also operates an additional 262 water quality stations in the Great Lakes drainage basin. In the past we have operated closely with the Great Lakes Basin Commission, the Upper Great Lakes Regional Commission, and the Center for Great Lakes Studies. We welcome the opportunity to assist your Task Force and hope we can work closely together in the future.

Sincerely,

Dr. Ken Holtje

DR. KEN HOLTJE, Branch Chief
Water Quality

Enclosure

U.S. ENVIRONMENTAL PROTECTION AGENCY

APPLICATION FOR FEDERAL ASSISTANCE

EPA PROJECT CONTROL NO.	DATE RECEIVED
FORMER FEDERAL NO. (If any)	P.E. NUMBER

THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION PROPOSAL REFERENCE NO. 1-27-54-55-5

APPENDIX B

PART I. GENERAL INFORMATION

1. APPLICANT

a. NAME: Charles E. Herdendorf, III

b. DEPARTMENT/DIVISION: The Ohio State University, Center for Lake Erie Area Research

c. CONGRESSIONAL DISTRICT: 15th

d. ADDRESS (Street or P.O. Box Number, Town/City, State and Zip Code): College of Biological Sciences, 484 W. 12th Avenue, Columbus, Ohio 43210

e. COUNTY: Franklin

2. PROJECT TITLE: Lake Erie Nutrient Control Program: An Assessment of its Effectiveness in Controlling Lake Eutrophication

3. CATALOG NUMBER AND TITLE OF EPA PROGRAM(S) TO WHICH THIS APPLICATION IS DIRECTED: 66.405 Water Pollution Control Research, Development, and Demonstration Grants

4. TOTAL COST OF PROJECT	5. TOTAL BUDGET PERIOD COST OF PROJECT	6. TOTAL EPA SHARE REQUESTED FOR BUDGET PERIOD
$ 330,014	$ 109,694	$ 99,450

7. PROJECT PERIOD: FROM 4-1-73 TO: 3-31-76

8. BUDGET PERIOD: FROM 4-1-73 TO: 3-31-74

9. TYPE OF APPLICANT (Check appropriate box or boxes)

a. GOVERNMENTAL AGENCY		b. NONGOVERNMENTAL		c. OTHER	
	STATE	X	NONPROFIT ORGANIZATION OR INSTITUTION		INDIVIDUAL
	INTERSTATE				
	MUNICIPAL		PROFIT-MAKING ORGANIZATION OR INSTITUTION		COLLEGE OR UNIVERSITY
	INTERMUNICIPAL				

10. TYPE OF GRANT

a. [X] NEW b. [ ] CONTINUATION (Current Grant Number _____)

11. PROJECT LOCATION	a. STATE	b. COUNTY
	c. MUNICIPALITY	d. CONGRESSIONAL DISTRICT
12. PROJECT AREA	a. STATE	b. COUNTY
	c. MUNICIPALITY	d. CONGRESSIONAL DISTRICT

	YES	NO
13. DOES PROJECT REQUIRE CLEARINGHOUSE NOTIFICATION IN ACCORDANCE WITH OFFICE OF MANAGEMENT AND BUDGET CIRCULAR A-95?		
14. HAS AN ENVIRONMENTAL ASSESSMENT BEEN MADE FOR THIS PROJECT OR FOR A COMPREHENSIVE PLAN WHICH INCLUDES THIS PROJECT?		
15. HAS AN ENVIRONMENTAL IMPACT STATEMENT BEEN MADE FOR THIS PROJECT OR FOR A CLASS OF PROJECTS INCLUDING THIS PROJECT?		
16. IS THE PROJECT COVERED BY A CURRENT FEDERALLY APPROVED PLAN?		

a. FEDERAL AGENCY b. DATE

17. APPLICANT CONTACT

a. NAME: Thomas J. Curtin

b. TITLE: Associate Director for Program Development Assistance

c. ADDRESS (Street, City, State and Zip Code): The Ohio State University Research Foundation, 1314 Kinnear Road, Columbus, Ohio 43212

d. PHONE NO. (Include Area Code): (614) 422-6248

18. OFFICIAL OR AGENCY TO WHOM CHECKS ARE TO BE MAILED

a. TITLE: John E. Spires, Fiscal Officer

b. ADDRESS (Street, City, State and Zip Code): The Ohio State University Research Foundation, 1314 Kinnear Road, Cols, OH 43212

19. [illegible] OTHER FEDERAL AGENCIES: No

Project I & - Appendix B

THE OHIO STATE UNIVERSITY RESEARCH F...
PROPOSAL REFERENCE NO. A-2656-5

PART II — SCHEDULE A - BUDGET

APPLICANT'S NAME: The Ohio State University Research Foundation

EPA PROJECT CONTROL NO.:

SECTION A - BUDGET BY SOURCE

	FUNDING SOURCE	FUNDS REQUIRED: BUDGET PERIOD	FUNDS REQUIRED: PROJECT PERIOD
EPA SOURCES			
	TOTAL	99,450	297,719
OTHER FEDERAL SOURCES			
	TOTAL		
NON FEDERAL SOURCES			
	TOTAL	10,244	32,295
	TOTAL BUDGET	109,694	330,014

SECTION B - BUDGET ESTIMATES FOR BALANCE OF THE PROJECT PERIOD

FUNDING SOURCE	ADDITIONAL SUPPORT TO COMPLETE PROJECTS — BUDGET PERIODS: FROM 4-1-74 (1) TO 3-31-75	FROM 4-1-75 (2) TO 3-31-76	FROM ____ (3) TO ____
EPA SUPPORT	99,182	99,087	
OTHER FEDERAL SUPPORT			
OTHER FUNDING SOURCE	10,756	11,295	
TOTALS	109,938	110,382	

SECTION C - FORECASTED CASH NEEDS BY QUARTER

FUNDS SOURCE	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	TOTAL
FEDERAL					
NON-FEDERAL					

THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION
PROPOSAL REFERENCE NO 6326-55-50

APPLICANT'S NAME
The Ohio State University Research Foundation

EPA PROJECT CONTROL NO

SECTION D - BUDGET BY COST CATEGORY OR PROGRAM ELEMENT

TABLE A. COST CATEGORY	PROJECT PERIOD		BUDGET PERIOD		EPA USE ONLY	
	TOTAL	REQUESTED	TOTAL	REQUESTED	ALLOWABLE BUDGET PERIOD COSTS	APPROVED GRANT AMOUNT
PERSONNEL	134,772	114,539	41,374	34,956		
FRINGE BENEFITS	6,278	3,668	1,991	1,163		
TRAVEL	9,000	9,000	3,000	3,000		
EQUIPMENT	22,000	22,000	12,000	12,000		
SUPPLIES	26,000	26,000	9,000	9,000		
CONTRACTUAL PERSONAL SERVICES						
CONSTRUCTION						
OTHER	69,000	69,000	23,000	23,000		
TOTAL DIRECT COSTS	267,050	244,207	90,365	83,119		
INDIRECT COSTS	62,964	53,512	19,329	16,331		
TOTALS	330,014	297,719	109,694	99,450		

TABLE B. PROGRAM ELEMENT	PROJECT PERIOD		BUDGET PERIOD		EPA USE ONLY	
	TOTAL	REQUESTED	TOTAL	REQUESTED	ALLOWABLE BUDGET PERIOD COSTS	APPROVED GRANT AMOUNT
TOTALS						

SECTION E - DETAILED ITEMIZATION OF DIRECT COSTS *(See Instructions)*

SECTION F - INDIRECT COSTS

INDIRECT COSTS ARE A
XX PREDETERMINED FIXED RATE ☐ PROVISIONAL RATE 46.72 % OF Salaries & Wages (base)

If the indirect cost rate is predetermined fixed, indicate the Federal agency that approved the cost allocation plan or if the indirect cost rate is a proposed provisional rate, indicate any Federal agency that has approved the use of such rate.

NAME OF AGENCY	DATE OF APPROVAL
Health, Education & Welfare	9-9-71

PART II

SCHEDULE B - BUDGET

(For construction projects and other projects involving land acquisition, land development, or the relocation of individuals and businesses.)

APPLICANT'S NAME	EPA PROJECT CONTROL NO.
The Ohio State University Research Foundation	

SECTION A - CALCULATION OF EPA GRANT

COST CLASSIFICATION	PROJECT PERIOD COST	BUDGET PERIOD COST	EPA USE ONLY AMOUNT APPROVED FOR BUDGET PERIOD
1. ADMINISTRATIVE EXPENSES			
2. LAND, STRUCTURES, RIGHT-OF-WAY			
3. ARCHITECTURAL/ENGINEERING BASIC FEES			
4. OTHER ARCHITECTURAL/ENGINEERING FEES			
5. CONSTRUCTION AND PROJECT IMPROVEMENT COST			
6. EQUIPMENT			
7. CONTINGENCIES			
8. RELOCATION PAYMENTS			
9. INDIRECT COSTS			
10. TOTALS — TOTALS			

SECTION B - INDIRECT COSTS

INDIRECT COSTS ARE A PREDETERMINED FIXED RATE OF _____ % OF _____ BASE.

NAME OF AGENCY THAT APPROVED THE RATE	DATE OF APPROVAL

SECTION C - BUDGET BY FUNDING SOURCE

	FUNDING SOURCE	FUNDS REQUIRED PROJECT PERIOD	FUNDS REQUIRED BUDGET PERIOD	DATE BUDGET PERIOD FUNDS AVAILABLE
EPA SOURCES				
	TOTAL			
OTHER FEDERAL SOURCES				
	TOTAL			
STATE	STATE AID — TOTAL			
FUNDS SUPPLIED BY APPLICANT	CASH			
	GENERAL OBLIGATION FUNDS			
	REVENUE BONDS CERTIFICATES			
	OTHER			
	TOTAL			
OTHER NON-FEDERAL SOURCES				
	TOTAL			
	TOTALS			

THE OHIO STATE UNIVERSITY Re...
PROPOSAL REFERENCE NO. ...

The undersigned representative certifies that the information submitted herewith is true and correct to the best of his knowledge and belief and that he is authorized to sign and submit this application.

The applicant agrees that if a grant is awarded on the basis of this application or any revision or amendment thereof, it will comply with all applicable statutory provisions and with the applicable terms, conditions, and procedures of the Environmental Protection Agency grant regulations (40 CFR Chapter I, Subchapter B) and of the grant agreement.

SIGNATURE OF AUTHORIZED REPRESENTATIVE	TYPED NAME AND TITLE
Ronald A. Wright	Ronald A. Wright, Director, Division for Program Development Assistance

DATE	PHONE NUMBER (Include Area Code)	PROPOSAL VALIDITY DATE
1/22/73	(614) 422-6243	

U.S. GOVERNMENT USE ONLY

AGENCY INTERNAL REFERRAL OFFICE	DATE RECEIVED	DATE REFERRED	REFERRED TO

AGENCY EXTERNAL REFERRAL	DATE RECEIVED	DATE REFERRED	REFERRED TO

INTRODUCTION

Objective

The Ohio State University proposes to conduct research on Lake Erie to determine the effectiveness of Federal, State and local nutrient control programs in reducing the over-enrichment of this important body of water. The prime objectives of this research will be the development of a system of indicators which will index the state of eutrophication in the lake as a function of time. This objective will be approached through a series of repetitive field surveys in the western and central basins of Lake Erie to monitor various trophic levels in the ecosystem of the lake and to analyze several physicochemical properties of the water and the sediment.

Background

The water from Lake Erie sustains the industrial complex which extends from Detroit to Buffalo, but the water as it is returned to the lake is highly enriched by municipal, agricultural and industrial waste products. Studies conducted in 1929 (Wright and Tidd, 1933) showed that the lake was already moderately rich in nutrients and was experiencing phytoplankton bloom in its western basin. Adjacent to the Detroit River mouth sensitive mayflies were being replaced by tubificid worms. In 1953 and 1955, during a period of thermal stratification, the western basin became severely depleted in oxygen, and the nymphs of the mayfly *Hexagenia* suffered a catastrophic mortality (Britt, 1955) and since that time they have been nearly absent from this part of the lake.

Since 1900 there has been an apparent increase in the concentrations of the major ions, including the nutrients phosphorus and nitrogen, in the waters of Lake Erie (Beeton, 1961). Davis (1964) showed that in central Lake Erie there has been a marked increase in the average number of cells of phytoplankton per milliliter. Since 1920 the lake has progressed from spring and fall algal blooms of moderate densities to blooms that yield high phytoplankton densities over most of the year; with the changes in magnitude and duration of the blooms have come changes in the species dominating the populations. Bottom fauna has also experienced similar changes typical of excessive organic enrichment. Species intolerant of the new conditions decreased while tolerant forms such as Oligochaeta worms and midge larvae (Chironomidae) became very abundant.

The concept of nutrient control for Lake Erie appears to have had its origin in 1965, when the U. S. Department of Health, Education and Welfare called a conference on pollution of Lake Erie and its tributaries under the authority granted in the Water Pollution Control Act of 1961. One of the recommendations of the conference was that a "Technical Committee" be established to evaluate water quality problems in Lake Erie related to nutrients and make recommendations to the conferees. In late 1965 the Lake Erie Enforcement Technical Committee was formally established and was directed to explain the problems related to nutrients and over-enrichment of Lake Erie. The Committee received information and advice from 26 leading authorities in water-oriented disciplines and after a year of study (Harlow, 1967) it issued a final report which contained the following conclusions:

1. The major pollution problem in Lake Erie results directly or indirectly from excess algae. These growths are stimulated by nutrients resulting from man's activities.

2. Silts containing nutrients are being contributed to the lake from dredging operations, urban and agricultural runoff and shore erosion.

3. Wind-induced currents transport nutrients and silt over wide areas of the lake.

4. Reliable long-term records for phosphorus and nitrogen are not available for Lake Erie waters.

5. The one nutrient most susceptible to control is phosphorus.

6. Phosphorus entering the lake originates from municipal wastes, rural land runoff and industrial wastes. About 80 percent is attributable to municipal wastes.

7. About 66 percent of the phosphorus in municipal wastes is from detergents.

8. Earlier data on phosphorus are difficult to interpret due to lack of information on the analytical procedure used and the method of expressing the results.

9. Water quality problems will likely occur when the concentrations of soluble phosphorus and inorganic nitrogen exceed 0.01 mg/l and 0.30 gm/1 respectively.

10. Water quality objectives should be established that will prevent nuisance algae conditions.

11. Even if water quality objectives are met, a reduction in frequency and intensity of algal nuisance conditions will be gradual.

12. Water quality objectives for Lake Erie should be established so that present high quality water will be preserved and the waters will be improved in the areas where nuisance conditions now exist.

13. Efforts to limit the growth of the filamentous alga Cladophora by the application of chemicals in the lake have been successful only on a small scale. Experience has demonstrated it is not feasible to apply these techniques to large areas. Chemical control of plankton algae is also impractical.

14. The quality of the Lake Erie fishery has declined. A significant factor in the decline of the more desirable species has been the destruction of a suitable environment within which they could successfully complete their life cycle and be maintained in abundance.

The Technical Committee recommended lower phosphate and inorganic nitrogen levels for Lake Erie and suggested that new treatment processes be developed and employed to effect high phosphorus removal. Based on these recommendations the FWPCA and later the FWQA and more recently the EPA as well as State and local agencies have embarked on a program to control the flow of nutrients to Lake Erie.

In 1966, the total phosphorus loading to Lake Erie was approximately 136,780 lbs/day (Table 1) with the Detroit area contributing over 40 percent of this amount. Because of the high loadings from this city, nutrient control was first begun here. Remus (1970) reported that new treatment facilities constructed by the Detroit Metropolitan Water Department had reduced the average orthophosphate in the effluent to the Detroit River from a high of 70,000 lbs/day in 1968 to less than 21,000 lbs/day in 1970.

Similar controls, though not as dramatic, have been initiated by many of the communities discharging to Lake Erie. The purpose of the proposed research is to assess the effects of this control on the ecology of Lake Erie.

TABLE 1
LAKE ERIE WASTE LOADING IN 1966[1]

Drainage Area	Phosphorus		BOD		Chloride	
	lbs/day	%	lbs/day	%	lbs/day	%
SE Michigan	55,000	41	1,180,000	45	8,100,000	43
Maumee Basin	21,000	15	390,000	15	760,000	4
N Central Ohio	8,500	6	110,000	4	400,000	2
Cleveland-Akron	25,000	18	470,000	12	1,700,000	9
NE Ohio	2,450	2	30,000	1	4,246,000	23
Pennsylvania	1,830	1	220,000	8	78,000	1
New York	5,150	4	140,000	5	620,000	3
Ontario	17,850	13	100,000	4	2,900,000	15
TOTAL	136,780		2,540,000		18,804,000	

[1] data from FWPCA (1968).

PROCEDURE

The philosophy of the proposed research is based on the principle that there are good reasons for the distributions and abundances of individual species to change with changes in their environments. Such changes through time and space of particular species and in the composition of communities are caused by persistent environmental changes (e.g. nutrient enrichment) and therefore, these biological changes can be used as biological indices of environmental alterations.

Field investigations will consist of five to seven cruises in the western and central basins of Lake Erie depending on weather and ice conditions. Approximately 50 stations will be established at equal intervals throughout the basins and will be spaced so as to provide a good characterization of the conditions in each basin. Sampling and analysis methods will be those given in "Standard Methods for the Examination of Water and Wastewater, 13th Edition" and will be supplemented by new techniques developed for the International Field Year on the Great Lakes (IFYGL) study of Lake Ontario. Parameters to be measured will include:

<u>Biological Sampling and Measurements</u>

1. Benthos
2. Plankton
3. Productivity - C^{14}
4. Chlorophyll
5. Total Organic Carbon
6. Microbial Activity/Methane Generation/Nitrogen Fixation

<u>Water Chemistry and Physical Measurements</u>

1. Wind Velocity and Direction
2. Wave Height and Approximate Period
3. Solar Radiation
4. Light Penetration
5. At each meter depth: (including surface)
   pH
   Temperature
   Conductivity
   Dissolved Oxygen
6. At one meter - mid depth - one meter above bottom.
   Chemical Oxygen Demand
   Total and Inorganic Phosphorous
   Total and Inorganic Nitrogen
   Alkalinity
7. Consistancy and Nature of Bottom Materials

Shipboard sampling will be supplemented by a monitoring program conducted from F. T. Stone Laboratory, The Ohio State University's biological field station on South Bass Island in Lake Erie. Water quality, plankton populations (including diatometer studies) and productivity investigations will be originated from this station. Stone Laboratory will also serve as the base facility for laboratory examination and identification of samples.

We propose that the monitoring program be established for a five-year period consisting of five complete segments. At the end of each one-year segment the effectivement of the nutrient abatement program will be assessed in light of the data generated by field monitoring and historical records. The annual assessments will be cumulative as data from previous years increases the reliability of the model.

Benthos

A measure of the trophic condition of Lake Erie will be calculated using a technique originated by Brinkhurst et al (1968) using benthic organisms. The taxa of Chironomidae, for this purpose, can be divided into various categories corresponding to their ability to withstand eutrophic conditions. The placement of particular taxa into the appropriate category posed no serious problem because in most cases their environment requirements are well-documented in the literature.

In 1950-52 Wood (1963) showed that the Mollusca composed 81 percent of the benthos of western Lake Erie (wet weight, shell excluded). He concluded that the distribution of 14 species found in that part of the lake was controlled by the fish which they parasitize and the conditions of the lake. We propose to repeat Wood's survey using identical methods. Dr. Wood has agreed to cooperate with such a resurvey and he feels confident that information gathered from this phase of the project will yield new parameters for assessing the changing condition of the lake.

Plankton

Knowledge of the species of algae found in Lake Erie is important for an understanding of the eutrophication process and for an evaluation of general water quality of the lake. Results from phytoplankton studies have indicated the eutrophic condition of the western basin of Lake Erie with algal populations decreasing from the western to the eastern basins. It is the intent of the proposed study to monitor the seasonal population changes, species and numbers, in the western and central basins and relate these

changes to nutrient availability. An attempt will also be made to relate the levels of chlorophyll in the water to concentration of orthophosphate-phosphorus using the method of Richards and Thompson (1952) as modified for use by the IFYGL Program on Lake Ontario.

Productivity

When primary production exceeds the consumption of organic matter it is usually the result of excessive inorganic nutrient levels in the system. Cody (1972) found a relatively high productivity rate for western Lake Erie using the carbon-14 method and he concluded that eutrophication is proceeding rapidly in that basin. We propose to extend these measurements to include the central basin of Lake Erie and thereby we hope to monitor any decrease in nutrient levels through decreased productivity.

Biological Nitrogen Fixation and Methane Generation

The impact of reducing inputs into a freshwater system is an important consideration in aquatic environment preservation. Among the indicators useful in the assessment of abatement procedures are certain microbial forms and their activities. Analysis of biological nitrogen fixation has shown that the forms capable of this activity are favored by environments in which nutrient input is significant. It has been demonstrated that the water contributed to Green Bay by the Fox River can be distinguished from the waters contributed by Lake Michigan by analyzing for biological nitrogen fixing capacity at sites along a grid pattern. If such boundaries can be distinguished where waters of differing nutrient load mix, then the decrease in nutrient load in a given body of water resulting from abatement procedures should also be assessable.

Another biological activity closely associated with the productive waters receiving nutrient inputs is the production of methane. Methane producing bacteria are primary stabilizers of fresh organic matter deposited in sediments. Thus the assessment of methane production in sediments will give an indication of the loading of those sediments with fresh readily decomposable organic matter. We propose the following research activities:

1. Biological nitrogen fixation capacity of the water column and sediments of selected grid sites will be assessed by the acetylene reduction technique. Both algal and bacterial activity will be determined throughout the sampling schedule.

2. Methane production of the sediments will be analyzed at selected grid sites by gas chromatographic techniques. The methane content of the water column at these same selected sites will be assessed by gas stripping followed by gas chromatography.

Utilization of Physicochemical Profiles to Monitor Oxygen Production and Consumption

The monthly collection of biological, chemical, and physical data at selected stations in the lake will allow a determination of long-term changes in the environment of quality, but do not, in themselves provide a valid indication of instantaneous rates of oxygen consumption or carbon fixation. However, in a sampling procedure which provides a time sequence of water column and meteorological data at given locations and times, there is the possibility of extracting additional information from the data by analysis of the station-to-station data as if it were taken over a given time sequence at a single "average" station. The type of analysis required is an unsteady state analysis of the oxygen, temperature, pH and alkalinity profiles obtained from stations in similar water masses, with the time interval between stations being the time interval used in the finite element unsteady state analysis. The objectives of this phase of the project are to:

1. Utilize wave, wind, solar energy and air temperature measurements, together with temperature profiles, estimate vertical mixing and surface transfer coefficients based on a station-to-station analysis of temperature profile changes.

2. Based on estimates from item 1 above, and/or independent correlations of mixing and transfer coefficients with wind and temperature conditions, estimate water column respiration and carbon fixation from a station-to-station analysis of oxygen, pH and alkalinity profile changes.

The basic raw data required for the intended analyses will be taken as an integral part of the main sampling program. A relatively simple two dimensional finite element unsteady state computer program will be used as the basis for computation of the carbon fixation and respiration components of the water column. As this approach has not been utilized previously, a decision as to whether to continue this approach will be made at the end of the first year of study.

FACILITIES

The Ohio State University has had a long history of activities related to the Great Lakes. For the past seventy-seven years, the University has maintained a biological field station adjacent to Lake Erie. In 1895 the first lake laboratory was established in Sandusky, Ohio and later moved to Cedar Point. This laboratory was then moved to its present home at Put-in-Bay on South Bass Island and Gibralter Island in 1925 with the founding of the Franz Theodore Stone Institute of Hydrobiology.

Throughout the years, the station has been a focal point for the training of hundreds of undergraduate and graduate students in aquatic sciences. Research there has contributed to the granting of more than one hundred masters and doctorate degrees. The station has also provided facilities for visiting professional scientists whose research was best conducted in the environs of Lake Erie. Research by these investigators at the lake laboratories of The Ohio State University has resulted in over six hundred scientific publications, theses and dissertations relating to the Great Lakes or other phases of aquatic science.

Stone Laboratory is one of the oldest freshwater research stations in the United States and provides researchers with unusual opportunities for studying various aspects of lake and island environments. The facilities include laboratory and office space, library, housing and dining hall. The laboratory is equipped with research apparatus for limnological and biological studies including ordinary laboratory and optical equipment, field sampling and measurement devices, sediment corers, fisheries gear and scale reading machines, current meters, recording fathometers, tanks and aquaria for holding aquatic organisms, and basic chemical supplies and apparatus. Three research boats from 20 to 40 feet in length, in addition to several smaller outboard motor boats, are especially equipped for scientific investigations and available for scheduled research projects.

In May 1971, The Ohio State University established a new Center for Lake Erie Area Research (CLEAR) to coordinate and expand programs of interdisciplinary research and technical services on scientific, technologic and socio-economic problems

associated with Lake Erie. The University views Lake Erie as perhaps Ohio's single most important natural resource and therefore vitally important to the economy and welfare of the people of Ohio. The rapid deterioration of the lake through pollution and eutrophication has grave socio-economic implications for the State. The Center for Lake Erie Area Research provides a single focal point within the University for unified planning, facilities development and logistical support for Lake Erie research conducted toward the solution of these problems.

Research vessels for this project are readily available from four sources: (1) The Ohio State University, (2) Ohio Department of Natural Resources, (3) Great Lakes Laboratory, SUNY-Buffalo and (4) Great Lakes Research Division, The University of Michigan. Contacts have been made with each of these organizations and tentative ship-use commitments have been received to adequately service this project.

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PROSPECTIVE INVESTIGATORS

Project Supervisor
Dr. Charles E. Herdendorf
Center for Lake Erie Area Research

Benthos:
Dr.N.Wilson Britt
Department of Entomology

Plankton:
Dr. Clarence E. Taft
Department of Botany

Productivity:
Dr. Richard A. Tubb
Department of Zoology

Microbial Activity:
Dr. James I. Frea
Department of Microbiology

Physicochemical Parameters:
Dr. Kenasaw Shumate
Department of Chemical Engineering

BIOGRAPHICAL DATA

Name: Charles Edward Herdendorf, III

Title: Director, Center for Lake Erie Area Research
Associate Professor of Zoology

Birthdate: October 2, 1939 Birthplace: Sheffield Lake, Ohio

Citizenship: U.S.A. Sex: Male

Education:

	School	Year	Field
B.S.	Ohio University	1961	Geology
M.S.	Ohio University	1963	Geology, sedimentology
Ph.D.	Ohio State University	1970	Zoology, limnology

Major Research Interest: Great Lakes research - sedimentology, physical limnology, mineral resources, shoreline erosion control, and aquatic ecology.

Professional Experience:

1971-present - Director, Center for Lake Erie Area Research and Associate Professor of Zoology, College of Biological Sciences, Ohio State University.

1964-1971 - Section Head, Lake Erie Section, Ohio Division of Geological Survey, Ohio Department of Natural Resources.

1961-1964 - Geologist, Lake Erie Section, Ohio Division of Geological Survey, Ohio Department of Natural Resources.

1960-1961 - Geologist, Division of Shore Erosion, Ohio Department of Natural Resources.

Consulting Experience:

1968-present - Ohio Coordinator for Limnology of Lakes and Embayments Work Group, Great Lake Basin Commission, Ann Arbor, Michigan.

1969-1970 - Geology and water resources for land use plan, Seneca Regional Planning Commission, Tiffin, Ohio.

Consulting Experience con't.

1969-1970 - Geology and water resources for land use plan, Crawford Regional Planning Commission, Bucyrus, Ohio.

1969 - Lake Erie shore erosion control plan, Office of Chief Engineer, Ohio Department of Natural Resources.

1969 - Water supply plan, Village of Bettsville, Ohio.

1968-1969 - Geology and water resources for land use plan, Henry Regional Planning Commission, Napoleon, Ohio.

1967 - Geology and water resources for land use plan, Erie Regional Planning Commission, Sandusky, Ohio.

Professional Organizations:

American Association for the Advancement of Science
American Institute of Professional Geologists
American Society of Limnology and Oceanography
Geological Society of America (fellow)
International Association for Great Lakes Research
International Oceanographic Foundation
Midwest Benthological Society
Ohio Academy of Science (fellow)
Societas Internationalis Limnologiae

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40) Herdendorf, C. E. 1971. Shorelands of Lake Erie In Lakeshore physiography and use. Coastal Zone and Shoreland Management in the Great Lakes. U.S. Army Corps of Eng., Chicago District. D-9.

41) Herdendorf, C. E. 1972. Investigations of the environmental impact of dredging within the Maumee River Estuary. Ohio Dept. Natural Resources, Div. of Geol. Surv. Rep. Invest. (in press).

Publications and Open File Reports con't.

42) Braidech, L. L. and C. E. Herdendorf. 1972. Lake Erie shore erosion control study in Lake County, Ohio. Ohio Dept. Natural Resources, Div. of Geol. Surv. Rep. Invest. (in press).

43) Herdendorf, C. E. and L. L. Braidech. 1972. Lake Erie shore erosion control study in Erie County, Ohio. Ohio Dept. Natural Resources, Div. of Geol. Surv. Rep. Invest. (in manuscript).

44) Anders, H. K., L. J. Charlesworth, C. E. Herdendorf, W. B. Jackson. T. L. Kovacik, C. S. Sikes, E. J. Skoch, L. J. Walters and D. K. Webb. 1972. Investigations of heavy metals in the western basin of Lake Erie. (in manuscript).

45) Brant, R. A. and C. E. Herdendorf. 1972. Delineation of Great Lakes estuaries. Proc. 15th Conf. Intern. Assoc. Great Lakes Research, Madison, Wis. (in press).

Name: Richard A. Tubb

Date and Place of Birth: December 18, 1931, Weatherford, Oklahoma

Citizenship: United States

Marital Status: Married, 1957, 2 children

Education:

1949 - Graduate from high school, Oklahoma City, Oklahoma

1958 - B. S. (Major - Geology) (Minor - Zoology) Oklahoma State University, Stillwater, Oklahoma

1960 - M. S. (Nat. Sci.) Oklahoma State University

1963 - Ph. D. (Zoology) Oklahoma State University

Brief Chronology of Employment:

1958 - 59 - High School Science Teacher, Prague, Oklahoma.

1959 - 60 - Academic Year Institute for High School Teachers, Oklahoma State University.

1960 - 62 - Graduate Research Assistant, Aquatic Biology Laboratory, Oklahoma State University.

1962 - University of Texas NSF traineeship at Texas Institute Marine Science.

1962 - 63 - NIH terminal year fellowship.

1963 - 66 - Assistant Professor of Biology, University of North Dakota, Grand Forks, North Dakota.

1966 - 67 - Assistant Leader, South Dakota Cooperative Fishery Unit, Brookings South Dakota.

1967 - Leader, Ohio Cooperative Fishery Unit, Columbus, Ohio.

1968 - Associate Professor, Ohio State University, Columbus, Ohio

1972 - Professor, Ohio State University, Columbus, Ohio

Military Service:

U.S. Navy, October, 1951 - September, 1955. 3rd Class P.O., teaching radio navigation to Naval cadets.

Research Grants:

Biogeochemistry of Devils Lake, North Dakota, North Dakota Water Resources grant, 1965-66, $8,600.

Publications:

Tubb, Richard A., F. A. Copes and C. Johnston. 1965. Fishes of the Sheyenne River of North Dakota. North Dakota Academy of Sciences. Vol. 19, pp. 120-128.

Tubb, Richard A. and Troy C. Dorris. 1965. Herbivorous insect populations in oil refinery effluent holding pond series. Limnology and Oceanography. Vol. 10, pp. 121-134.

Copes, F. A. and R. A. Tubb. 1966. Fishes of the Red River tributaries in North Dakota. Contributions of Inst. Ecol. Studies. Vol. 1,26pp.

Tubb, Richard A. 1966. Effects of winter aeration of Turtle Mountain Lakes of North Dakota. North Dakota Game & Fish Dept. Dingell-Johnson Project R-2-R-13. Report 1093. 25pp.

Kochsiek, Kenneth and Richard A. Tubb. 1967. Salinity tolerances of three fish, Pimephales promelas, Fundulus diaphanus, and Culaea inconstans. Proceedings of South Dakota Academy of Science. Vol. 46, pp. 95-99.

Armstrong, Richard and Richard A. Tubb. 1967. Uptake of glyciene and phenylalanine in some fresh-water invertebrates. North Dakota Academy of Science. Vol. 21, pp. 103-111.

Tubb, R. A., S. H. Taub and R. E. Deis. 1968. Potential of a strip-mined area for fish and wildlife reclamation. (aquatic). O.S.U. Research Foundation. Project #2296. Contract #14-16-0008-771. 84pp.

Tidd, Wilbur M. and R. A. Tubb. 1970. Abstract. Investigations of Whirling Disease in Ohio. Jl. of Parasitology. Vol. 56 No. 4 Section II, pp. 344-45.

Fikes, Martha F. and R. A. Tubb. 1971. Amblema plicata as a pesticide monitor. Proceedings of a Symposium on Rare and Endangered Mollusks (Naiads) of the U. S. Ed. by S. E. Jorgensen and R. W. Sharp. U. S. Dept. of Interior Fish and Wildlife Service Bureau of Sport Fisheries and Wildlife Region 3 p. 34-37.

Prasher, Janis B., Wilbur M. Tidd and Richard A. Tubb. 1971. Techniques for extracting and quantitatively studying the spore stage of the protozoan Myxosoma cerebralis. The Progressive Fish-Culturist. Vol. 33. No. 4, pp.193-196.

Fikes, Martha H. and Richard A. Tubb. 1972. Dieldrin uptake in the three-ridge naiad. Jl. of Wildlife Management. (in press Jl. Wild. Mgmt.)

Societies:

Phi Kappa Phi
Sigma Xi
American Society of Limnology and Oceanography
International Society of Limnology
American Fisheries Society
Wildlife Society
Phi Sigma
Sigma Gamma Epsilon (Honorary Geological Society)
American Institute of Fishery Research Biologists

Research Interests:

Chemical and physical factors affecting populations of aquatic animals, population dynamics of fish and energy flows in aquatic ecosystems.

Teaching Experience in the following courses:

General Biology, University of North Dakota 1963, 1964, 1965

Biology for High School Teachers (A.Y.I. course sponsored by N.S.F.)

Limnology, University of North Dakota 1964, 1965

Fisheries Biology, University of North Dakota 1965

Ichthyology, University of North Dakota 1964

Aquatic Ecology, University of South Dakota 1966

Fish Ecology, F. T. Stone Laboratory 1968, 1969

Other - with Dr. Robert Seabloom, I organized an undergraduate program in Wildlife and Fish Management at the University of North Dakota in 1964.

Limnology, Ohio State University 1970, 1971

Supervision of the Following Studies by Graduate Students:

1. Copes, F. A. 1965. Fishes of the Red River tributaries in North Dakota. M. S. thesis. University of North Dakota. p.57.

2. Kochsick, K. A. 1965. A study of the salinity tolerances of three fishes occurring in northeastern North Dakota. Pimephales promelas, Culaea inconstans and Fundulus diaphanus. M. S. thesis. University of North Dakota. p.55.

3. Armstrong, Richard. 1965. Uptake of amino acids by benthic invertebrates. M. S. thesis. University of North Dakota. p.45.

Supervision of the Following Studies by Graduate Students: (cont'd)

4. Anderson, David W. 1966. A study of the productivity and plankton of Devils Lake, North Dakota. M. S. thesis. University of North Dakota. p.45.

5. Felix, Thomas. 1965. Movement of forage fishes in a small South Dakota stream. M. S. thesis. South Dakota State University. 48p.

6. Gartman, Donald K. 1969. The abundance and distribution of zooplankton in Hoover Reservoir, Ohio. M. S. thesis. The Ohio State University. 48p.

7. Birch, Thomas J. 1969. Sources of pollution in the drainage basin contributing to the eutrophication of Hoover Reservoir, Ohio. Ph. D. dissertation. The Ohio State University. 126pp. (coadvisor)

8. Prasher, Janis B. 1970. Techniques for extracting and quantitatively studying the spore stage of the protozoan parasite Myxosoma cerebralis. M. S. thesis. The Ohio State University. 30p. (coadvisor)

9. Judd, John B. 1971. The effects of ecological changes on the largemouth bass of Buckeye Lake, Ohio. p.86.

10. Fikes, Martha H. 1971. The uptake retention and release of dieldrin in the gills of the naiad mollusk Amblema plicata. M. S. thesis. The Ohio State University. 21p.

11. Cody, Terence E. 1972. Primary Productivity relationships in the western basin of Lake Erie. Ph. D. dissertation. The Ohio State University. (coadvisor)

Other duties:

1. Associate Editor (fisheries) Journal Wildlife Managment, 1968-70.

2. Chairman, Fisheries Publication Award Committee, Wildlife Soc., 1970.

3. American Fisheries Society Resolution Committee, 1970.

4. Member of Graduate Committee, Zoology Dept. The Ohio State University, 1970-72.

5. Member of Pesticide Advisory Committee, The Ohio State University, 1970.

6. Ohio Water Commission, Technical Advisory Committee, 1971-

7. Testimony before The National Academy of Science, Water Quality Advisory Panel, 1971.

8. President - Ohio Chapter of Wildlife Society, 1972.

Supervision of the Following Studies in Progress:

1. An environmental evaluation of a nuclear power plant on Lake Erie. 1969-1972 with L. S. Putnam. Funded by D.J. Fish Restoration Act.

2. Impact of fish hatcheries effluent on receiving streams over a large geographic area. 1971-1972. Research Foundation.

3. Uptake of mercury by Cladophora in western Lake Erie. 1971-with Robert Burkett.

4. Detection of Myxosoma cerebralis spores in trout-holding facilities. 1970-1972 with Wilbur Tidd. NOAA National Marine Fisheries.

In addition to these studies I am supervising several other studies conducted by graduate students at various stages of completion.

Special Awards:

U.S. Department of the Interior - Superior Service Award-Presented 8/23/72

Regional Achievement Award - Presented 8/23/72

BIOGRAPHICAL SKETCH

Name: James I. Frea, Associate Professor of Microbiology

Place of Birth: Sturgeon Bay, Wisconsin

Birthdate: March 1, 1937

Education:	University of Wisconsin, Madison, Wisconsin	B.S.	1959
	University of Wisconsin, Madison, Wisconsin	M.S.	1961
	University of Wisconsin, Madison, Wisconsin	Ph.D.	1963

Honors: Phi Eta Sigma, Phi Kappa Phi, Alpha Zeta, Phi Lambda Upsilon, National Science Foundation Cooperative Fellowship, National Science Foundation Regular Pre-Doctoral Fellowship

Major Research Interest: Microbial physiology
Actinomycete physiology
Biochemical ecology

Research and/or Professional Experience:

Associate Professor of Microbiology, Academic Faculty of Microbial and Cellular Biology, Ohio State University, 1969 to present.
Assistant Professor of Microbiology, Academic Faculty of Microbial and Cellular Biology, Ohio State University, 1965 - 1969.
Chief, Microbiology Section, First US Army Medical Laboratory, 1963-1965.
Acting Chief, Chemistry Division, First US Army Medical Laboratory, Short periods, 1963-1965.
National Science Foundation Pre-doctoral Fellow in Bacteriology and Biochemistry, University of Wisconsin, 1959-1963.
Teaching Assistant in Bacteriology and Biochemistry, University of Wisconsin, 1961-1962.
Member: American Society for Microbiology; The Society of Sigma Xi; Ohio Branch of American Society for Microbiology; American Chemical Society; American Association for the Advancement of Science.
Doctoral research problem: "Isolation of Staphylococcal Enterotoxin."

Personal Publications:

Frea, J. I., Elizabeth McCoy and F.M. Strong, 1963. Purification of type B staphylococcal enterotoxin. J. Bacteriol. 86:1303-1313.
Frea, J. I., Elizabeth McCoy and F.M. Strong, 1963. Purification of staphylococcal enterotoxin. Federation Proc. 22:482.
Ph.D. Thesis, University of Wisconsin, 1963. Isolation of staphylococcal enterotoxin.
M.S. Thesis, University of Wisconsin, 1961. A study of the environmental and nutritional factors in staphylococcal enterotoxin production.
Bednar, Joyce J. and James I. Frea, 1967. DNA base composition of Streptomyces fradiae and its asporogenous variant. Bacteriol. Proc. 1967:173.
Pfister, R.M., P.R. Dugan and J.I. Frea, 1968. Methods for separation and enumeration of microscopic particulate fractions in water and the relationship to aquatic microflora. Abstracts Eleventh Conf. on Great Lakes Res. p. 58.

Pfister, R. M., P. R. Dugan and J. I. Frea, 1968. Particulate fractions in water and the relationship to aquatic microflora. Proc. Eleventh Conf. on Great Lakes Res. 1968: 111-116.

Frea, J. I., M. S. Rheins, and R. M. Pfister, 1969. Survey of the potential gram character of bacteria by the KOH procedure, J. Comp. Lab. Med. 3:5.

Pfister, R. M., P. R. Dugan, and J. I. Frea, 1969. Microparticulates: Isolation from water and identification of associated chlorinated pesticides, Science 166:878.

Pfister, R. M., J. I. Frea, P. R. Dugan, Kathleen Zaebst, Jo Ann Duchene, R. Kennedy, and Tatia McNair, 1970. Lake Erie Microparticulate, pesticide and microorganism interactions, Abs. Thirteenth Conf. on Great Lakes Res. 1970: 38.

Howard, D. L., J. I. Frea, R. M. Pfister, and P. R. Dugan, 1970. Biological nitrogen fixation potential in Lake Erie, Abs. Thirteenth Conf. on Great Lakes Res. 1970: 14.

Leshniowsky, W., P. R. Dugan, R. M. Pfister, and J. I. Frea, 1970. Accumulation of chlorinated hydrocarbons by microbial floc and its ecological implication, Abs. Thirteenth Conf. on Great Lakes Res. 1970: 37.

Danford, T. R. and J. I. Frea, 1970. Actinomycete protoplast formation in high-salt media, Bacteriol. Proc. 1970: 37.

Ebner, Joyce B. and J. I. Frea, 1970. Heat resistance during the life cycle of Streptomyces fradiae, Microbios. 5:43.

Howard, D. L., J. I. Frea, R. M. Pfister, and P. R. Dugan, 1970. Biological nitrogen fixation in Lake Erie, Science 169:61.

Leshniowsky, W. O., P. R. Dugan, R. M. Pfister, J. I. Frea, and C. I. Randles, 1970. Aldrin: Removal from lake water by flocculent bacteria, Science 169:993.

Pfister, R. M., J. I. Frea, P. R. Dugan, C. I. Randles, K. Zaebst, J. Duchene, T. McNair, and R. Kennedy, 1970. Chlorinated hydrocarbon, microparticulate effects on microorganisms isolated from Lake Erie, Proc. Thirteenth Conf. on Great Lakes Res. 1970: 82-92.

Dugan, P. R., J. I. Frea, and R. M. Pfister, 1970. Some microbial-chemical interactions as systems parameters in Lake Erie. In proceedings of the 4th Symposium on Water Resources Research of the Ohio State University, Water Resources Center.

Dugan, P. R., R. M. Pfister, and J. I. Frea, 1970. Implications of microbial polymer synthesis in waste treatment and lake eutrophication, Proc. 5th International Conf. on Water Pollution (in press).

Leshniowsky, W. O., P. R. Dugan, R. M. Pfister, J. I. Frea, and C. I. Randles, 1970. Adsorption of chlorinated hydrocarbon pesticides by microbial floc and lake sediment and its ecological implications. Proc. Thirteenth Conf. on Great Lakes Res. 1970 (in press).

Howard, D. L. and J.I. Frea, 1971. Biological methane activity in Lake Erie. Abs. Fourteenth Conf. on Great Lakes Res. 1971:25.

McCabe, Patricia A. and J. I. Frea, 1971. Interaction of a clay mineral, microbial cells and enzymes in the degradation of solid organic materials. Abs. Fourteenth Conf. on Great Lakes Res. 1971:34.

BIOGRAPHICAL DATA

Name: N. Wilson Britt

Title: Professor, Entomology, The Ohio State University

Birthdate: January 3, 1913 Birthplace: Lucas, Kentucky

Citizenship: U.S.A. Sex: Male

Education:

	School	Year
B.S.	Western Kentucky State College	1939
M.S.	The Ohio State University	1947
Ph.D.	The Ohio State University	1950

Major Research Interest: Aquatic Entomology, especially Ephemeroptera, Limnology, especially of Lake Erie.

Professional Experience:

Thirty-One years teaching expeirnece including elementary and secondary public schools, Army Air Force, and University teaching for the last 21 years. Asst. Prof., Hydrobiology, Franz Theodore Stone Institute of Hydrobiology, the Ohio State University, July 1950-Sept. 1955. Asst. Prof. Zool. & Entomol., The Ohio State University, 1955-1959. Assoc. Prof. Zool. & Entomol., The Ohio State University, 1959-1968. Prof. 1968-Present. Research (1) Life history and ecology of the aquatic insects of Lake Erie - principally the Ephemeroptera. (2) Studies dealing with the physical, chemical, and biological factors influencing eutrophication of Lake Erie.

Publications:

1948 Observations on the life history of the collembolan Achorutes armatus. Abstracts of Masters Theses, No. 55, The Ohio State University Press, 1948.

1951 Observations on the life history of the collembolan Achorutes armatus. American Microscopical Society 70(2):119-132. April 1951.

1951 Observations on the life history of the collembolan, Achorutes armatus. Trans. Amer. Micros. Soc. 70(2): 119-132, 1951. Biological Abstracts 25(10):Abst. No. 32474

Publications con't.

1953 Differences between measurements of living and preserved aquatic nymphs caused by injury and preservatives. Ecology 34(4):802-803. October 1953.

1953 The life history and ecology of the white may fly, Ephoron album Say, in Lake Erie. Abstracts of Doctoral Dissertations No. 64. Ohio State University Press, 1953.

1954 Mayflies - friends or foes! The Ohio Conservation Bulletin 18(5):2-3, 31-32, May 1954.

1954 Pseudo tides in Lake Erie. Inland Seas 10(4):294, photographs p. 265. Winter 1954.

1954 Differences between measurements of living and preserved aquatic nymphs caused by injury and preservatives. Ecology 34(4):802-803. 1953 Biological Abstracts 28(12): Abst. No. 28863.

1955 Stratification in western Lake Erie in summer of 1953; effects on the Hexagenia (Ephemeroptera) population. Ecology 36(2):239-244. April 1955.

1955 New method of collecting bottom fauna from shoals or rubble bottom of lakes and streams. Ecology 36(3):524-525.

1955 Hexagenia (Ephemeroptera) population recovery in western Lake Erie following the 1953 catastrophe. Ecology 36(3): 520-522.

1956 Extension of the range of Eumeces fasciatus in Ohio Copeia 1956, No. 1, p. 54.

1956 Bibliography of physical limnology 1781-1954. James L. Verber. Ohio Department of Natural Resources, Division of Shore Erosion, Division of Geological Survey, Report of Investigations No. 25. (Contribution No. 4 Lake Erie Geological Research Program.) 1955. Review in Ohio Jour. Sci. 56(2):124, March, 1956.

1956 Stratification in western Lake Erie in summer of 1953: effects on the Hexagenia (Ephemeroptera) population. Ecology 36(2).239-244. Illus. 1955. Biological Abstracts 30(7): Abst. No. 18669.

Publications con't.

1956 Hexagenia (Ephemeroptera) population recovery in western Lake Erie following the 1953 catastrophe. Ecology 36(3): 520-522. Illus. 1955. Biological Abstracts 30(8):Abst. No. 21725.

1956 New methods of collecting bottom fauna from shoals or rubble bottoms of lakes and streams. Ecology 36(3): 524-525. Illus. 1955. Biological Abstracts 30(8): Abst. No. 21726.

1957 Range extension of Eumeces fasciatus (Scincidae) into Sandusky County, Ohio. Ohio Jour. Sci. 57(2):90.

1957 Handbook of snakes of the United States and Canada. Albert Hazen Wright and Anna Allen Wright. Comstock Publishing Associates, Ithaca, New York, 1947. Review in Ohio Jour. Sci. 57(4):233.

1960 Co-author with William A. Brungs. An albino five lined skink, Eumeces fasciatus Linnaeus. Copeia 1960(4): 369-370.

1961 Extended limnological studies in western Lake Erie sponsored by the Natural Resources Institute of the Ohio State University. Abstract of paper presented at Fourth Conference on Great Lakes Research, published in Proceedings Fourth Conference on Great Lakes Research 1961 Great Lakes Research Division Publication No. 10. University of Michigan, Ann Arbor.

1962 Biology of two species of Lake Erie mayflies, Ephoron album (Say) and Ephemera simulars Walker. Bull. Ohio Biol. Survey, New Series, Vol. 1, No. 5, p. 1-70.

1962 Biology of two species of Lake Erie mayfiles. Ephoron album (Say) and Ephemera simulars Walker. (Ephemeroptera). Bull. Ohio Biological Survey, New Series 1(5):1-72. Illus. 1962. Biological Abstratts, Vol. 40(5) Abstract No. 21258- 1962.

1963 Some changes in the bottom fauna of the island area of western Lake Erie in the decade 1953-1963, with special reference to the aquatic insects. Great Lakes Research Division, Institute of Science and Technology, University of Michigan. Publication No. 10. Proceedings Sixth Conference on Great Lakes Research. (An abstract of a paper presented at the Sixth Conference on Great Lakes Research).

Publications con't.

1965 A brief note on the distribution of the polychaete, Manayunkia speciosa Leidy, in western Lake Erie. The Ohio Journal of Science 65(4):175-176.

1966 Benthic changes in the island area of western Lake Erie during the past 15 years as indicated by 1959-1965 bottom fauna collections. The Wheaton Club Bulletin, New Series Vol. 11: 14-15. September 1966.

1966 Britt, N. Wilson and James T. Addis. 1966. Limnological studies of the island area of western Lake Erie 1959-1965. Special Report of the Natural Resources Institute, The Ohio State University. pp. I-IV, 1-147. Feb. 1966.

Although about 50 copies of this report were distributed to various State and Federal agencies it was not generally distributed to the public and may not be considered a publication in the strictest sense. It does have a section dealing with the aquatic insects inhabiting the bottom of the lake.

1968 Water and algae; world problems. Clarence E. Taft. Education Publishers, Inc., Chicago, Illinois. 1965. XX + 236 P. illus. $5.50. Review in Ohio Journal of Science 68(1):59.

1968 Britt, N. Wilson, Edwin J. Skoch, and Kenneth R. Smith, 1968. Record low dissolved oxygen in the island area of Lake Erie. The Ohio Jour. of Sci. 68(3):175-179.

1969 Skoch, Edwin J. and N. Wilson Britt. 1969. Monthly variations in phosphate and related chemicals found in the sediment in the island area of Lake Erie, 1967-68, with reference to samples collected in 1964, 1965, and 1966. Proc. 12th Conf. Great Lakes Res. 1969:329-340. Internat. Assoc. Great Lakes Res.

1970 Britt, N. W., Edwin J. Skoch and Kenneth R. Smith. 1970. Relationships between phosphate and other chemicals at the water-substrate interface in Lake Erie. Project Completion Report No. 333X. U.S. Dept. Interior Contract No. A-008-Ohio. Printed by State of Ohio Water Resources Center, Ohio State University.

BIOGRAPHICAL DATA

Name:

Clarence E. Taft

Nationality: U. S. Citizen

Social Security Number: 297-40-3064

Birthdate:

November 13, 1906

Birthplace:

Romeo, Michigan

Education:

Michigan State Normal College, Ypsilanti, Michigan	A.B.	1929
University of Oklahoma, Norman, Oklahoma	M.S.	1931
Ohio State University, Columbus, Ohio	Ph.D.	1934

Honors:

Phi Sigma
Sigma Xi
Gamma Sigma Delty
Phi Epsilon Phi

Major Research Interest:

Taxonomy and ecology of fresh-water algae

Research and/or Professional Experience:

Instructor in Botany, The Ohio State University, 1934-1940
Assistant Professor of Botany, The Ohio State Univ., 1940-1945
Associate Professor of Botany, The Ohio State Univ., 1945-1951
Professor of Botany, The Ohio State Univ., 1951--
Exchange Instructor in Botany, Cornell Univ., Spring Quarter, 1937
Instructor in Botany, The Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, Summers, 1938 and 1940
Assistant Professor in Botany, The Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, Summers, 1941 and 1942
Associate Professor in Botany, The Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, Summer, 1951
Professor in Botany, The Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, Summers, 1952, 1954, 1956, 1958, 1960, 1962, 1964, 1966
Investigator for the Balyeat Hay Fever Clinic, Oklahoma City, Okla., 1930
University Scholar in Botany, The Ohio State Univ., 1931-1932
Assistant Director and Professor, The International School of America, Columbus, Ohio, Sept. 1, 1958 to Oct. 1, 1960
Acting Director, Stone Laboratory, OSU, Put-in-Bay, Ohio July 24 - Sept. 1, 1964
Principal Investigator - NIH Grant WP-00317-05 (R.F. 1964), The Deatoms of Western Lake Erie
Cladophora in relation to pollution in Western Lake Erie, U.S. Dept. Interior W-111, Grant funded through Water Resources Center, The Ohio State University

Publications:

List attached

Publications;

The Desmids of Oklahoma, Okla. Biol. Survey Bull. 3(3):277-321, 1931.
The Rotifers of Oklahoma, Ohio Journal of Science. 32(6): 492-504, 1933.
Balyeat, Ray M., T. R. Stemen and C. E. Taft. Comparative Pollen, mold, butterfly and moth emanation content of air. Journ. Allergy. 3(3): 234-237, 1932.
The Desmids of Oklahoma II. Trans. Amer. Micros. Soc. 53(2): 95-101, 1934.
New Species of Zygnemataceae (Transeau, Riffany, Taft and Li) Trans. Amer. Micros. Soc. 53(3): 208-230, 1934.
The Oedogoniaceae of Oklahoma, including new species and varieties. Bull. Torrey Bot. Club, 62: 281-290, 1935.
The Heterophyceae and Chlorophyceae of Oklahoma. Abstract of Doctor's Dissertation, No. 16. The Ohio State Univ., 1935.
The Desmids of Oklahoma III. Trans. Amer. Micros. Soc. 56(4): 397-404, 1937.
The Life History of a new species of Mesotaenium. Bull. Torrey Bot. Club. 64: 75-79, 1937.
A new species of Vaucheria. Bull Torrev Bot. Club 64: 557, 1937.
Additions to the Algae of Michigan. Bull. Torrey Bot. Club 66: 77-85, 1939.
Asexual and Sexual reproduction in Platydorina caudata Kofoid. Trans. Amer. Micros. Soc. 59(1): 1-11, 1940.
Additions to the Algae of Oklahoma. Proc. Okla. Sci. 20: 49-54, 1940
Inversion of the developing Coenobium in Pandorian Morum. Trans. Amer. Micros. Soc. 60(3): 327-328, 1941.
New species of Cylindrocystis. Ohio Jour. Sci. 42(3): 122, 1942.
Additions to the algae of the West end of Lake Erie. Ohio Jour. Sci. 42(6): 251-256, 1942.
A new asymmetric Cosmatium. Ohio Jour. Sci. 44(1): 25, 1944.
New species of Zygnemataceae. Ohio Jour. Sci. 44(5): 238, 1944.
The similarity existing between some algae and some pollens with a further note concerning Phytomorula regularis Kofoid. Ohio Jour. Sci. 45(1): 16-17, 1945.
Pectyodictyon, a new genus in the Family Scenedesmaceae. Trans. Amer. Micros. Soc. 64(1): 25-28, 1945.
The validity of the algal genus Thamniastrum. Bull. Torrey Bot. Club 72(3): 246-247, 1945.
The algolosist and water sanitation. Ohio. Jour. Sci. 45(3): 97-102, 1945.
The Desmids of the west end of Kale Erie. Ohio Jour. Sci. 45(5): 180-205, 1945.
Some Oedogoniaceae and Zygnomataceae from Texas and Louisiana. Trans. Amer. Micros. Soc. 45(1): 18-26, 1946.
Monostroma Wittrockii in Ohio. Ohio Jour. Sci. 46(3): 163-164, 1946.
Some algae, including new species from New Mexico. Ohio Jour. Sci. 47(2): 85-87, 1947.
Spirogyra hollandiae, a new species from New Guinea. Ohio Jour. Sci.
A bibliography of American algae literature from 1939 to 1946. Revue Algalogique. In Press.
New, rare, and otherwise interesting algae. Trans. Amer. Micros. Soc. 68(3): 208-216, 1949.
Two papers on algae in water supplies in Technical Journals
The algae control program within the Columbus City Division of Water. Jour. Amer. Water Works Assoc.
The algologists part in city and industrial water supply problems. Limnological aspects of water supply and waste disposal symposium. A.A.A.S., 1949.

Publications: (continued)

A key for the field identification of some algae. Turtox News 35(4): 104-197, 1957.

Normandin, Robert and Clearence E. Taft. A new species of Basicladia from the snail Viviparus Malleatus Reeve. Ohio Jour. Sci. 59(1): 58-62, 1959.

A revised key for the field identification of some genera of algae. Turtox News, April, 1961.

New records of algae from the west end of Lake Erie. Ohio Jour. Sci. 64(1): 43-50, 1964.

The occurrence of Monostroma and Enteromorpha in Ohio. Ohio Jour. Sci. 64(4): 272-274, 1964.

Collecting algae for winter teaching. Turtox News, October, 1964.

Water and algae - World Problems. A Book. Educational Publishers, Inc. Chicago, Ill., 1965.

Workbook in General Botany, Senior author. Harper & Row, New York, 1967.

Algae in western Lake Erie. In Review. (A Book)

Algae from western Lake Erie. Ohio Jour. Sci. 68(2) 80-83, 1968. Co-author - W. Jack Kishler.

Biographical Sketch

Kenesaw Sloan Shumate, Associate Professor, Chemical Engineering

Born: June 25, 1937, Columbus, Ohio

Degrees:

B. Sc. Case Institute of Technology, Civil Engineering, 1959
M. Sc. The Ohio State University, Sanitary Engineering, 1961
Ph. D. The Ohio State University, Sanitary Engineering, 1963

Research and Teaching Experience:

Assistant Professor of Civil Engineering, The Ohio State University, 1963-1968
Associate Professor of Civil Engineering, The Ohio State University, July, 1968; June, 1972
Associate Professor of Chemical Engineering, The Ohio State University, July, 1972 - present

Administrative Experience:

Acting Director, The Ohio State University Water Resources Center, September, 1966 through August, 1967; and June, 1969 through August, 1969
Director, The Ohio State University Water Resources Center, August, 1971 to present

Professional Societies:

American Institute of Chemical Engineers
Mining and Metallurgical Institute of Japan
Tau Beta Pi
Sigma Xi
Chi Epsilon

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APPENDIX R
(REF. 10)

ENVIRONMENTAL PROTECTION AGENCY

REPLY TO ATTN OF: Tudor T. Davies, Director
Grosse Ile Laboratory

DATE: February 21, 1973

SUBJECT: Monitoring on Lakes Michigan, Erie and Ontario

TO:
DeWitt Johnson,
EPA, Region V

The Office of Research and Monitoring and Region II are currently engaged in an extensive study of Lake Ontario. The field portion of the study will be completed by July 1973. Data interpretation will require an additional two years. This study should provide a model from which a monitoring program could be developed. Enclosed is a copy of one of the IFYGL reports that summarizes the current studies.

Our present plans call for a follow-up study on Lake Ontario for the biological assessment of the effectiveness of nutrient control measurements. This study would focus primarily on the biotic community and supporting nutrients.

In Lake Erie we are funding a study to develop a model of the transport and dispersion of nutrients in the nearshore area of the lake. The funding of a study on the Lake Erie nutrient control program: "An Assessment of Its Effectiveness in Controlling Lake Eutrophication" is in question at this time because of the uncertainty of the FY 73 funds. If this project is not started in 73, it will certainly be started in 74. This project will run for several years with annual reports being submitted shortly after the completion of each field season. Enclosed is a copy of the grant application from Ohio State University for the study of Lake Erie.

Our efforts on Lake Michigan will include the following types of studies: As you are aware, Cladophora is a serious problem on Lake Michigan; therefore, we are anticipating sponsoring a grant on the nutrient and growth requirements of this alga. In addition, we hope to be able to fund two additional grants in this field; one of which is to measure the abundance of Cladophora with remote sensing and the other is a taxonomic description of the benthic algae of the Great Lakes.

As in the other lower lakes, we will be funding a grant to determine the effectiveness of the nutrient control measurements through changes in the biota and certain chemical parameters. This grant will either be funded in FY 73 or 74.

One other area that may be of interest to you in which we are anticipating some work is in the field of hazardous materials. This would be a fairly broad study to determine the significance, pathways and possible control measures.

I am also enclosing a copy of abstracts that were distributed at the ICMSE Conference, which pertains to the participation of other federal agencies in Great Lakes research.

I would suggest that you visit the Canada Centre for Inland Waters to obtain their program for sampling of the Great Lakes. They generally operate in a three-year pattern.

As you are formulating your monitoring program, please feel free to contact us as to the nature of our program.

Tudor T. Davies

Encls.

Environment Canada Environnement Canada

APPENDIX-S

Your file Votre référence

MEMORANDUM NOTE DE SERVICE

Our file Notre référence

TO. A. Dr. A.T. Prince, Director-General, Inland Waters Directorate.

FROM: DE J.P. Lively, Water Quality Branch.

SUBJECT: SUJET Phenol - I.J.C. Reference Canada - U.S.

The Subcommittee or Working Group on the above subject met at the CCIW on November 21, 1972 to establish a standard method for determining phenol. Representatives of the U.S. Environmental Protection Agency, Cincinnati and Grosse Ile; the State of Michigan; the Ontario Ministry of the Environment (OWRC); and our own people attended. A list of those attending is attached.

The following summarizes the recommendations of the Working Group.

1. Agreement was reached on methods to sample, preserve and analyse Great Lakes waters for phenol determination and these methods are recommended for studies connected with the above subject. A copy is attached.

2. Because the method of analysis of phenols has its limitations, the Group strongly recommends that a research project on phenol be carried out. The objective of this project is to characterize the phenolic compounds which affect the water quality in the Great Lakes system so that these compounds can be identified and quantified on a regular basis.

3. The Group recommends that a standing committee or Subcommittee be struck under the Water Quality Board of the International Joint Commission to establish and upgrade standard methods of water analysis for Canada-U.S. Water Quality Agreement studies.

Since the initial request was to resolve the phenol question only, I do not intend to have the group meet again, unless, of course, you advise otherwise.

J.P. Lively

J.P. Lively.

JPL:pd

c.c. R.H. Millest
A.R. LeFeuvre

Encl.

December 5, 1972.

F-2013 (REV. 1/72)

I.J.C. Meeting - November 21, 1972

Attending

J.P. Lively	Canada, DOE, Ottawa
W.J. Traversy	Canada, DOE, Burlington
R. Booth	U.S., E.P.A., Cincinnati, Ohio
C.T. Elly	U.S., E.P.A., Grosse Ile, Michigan
R. Kreuger	Michigan State

Amendment

I.J.C. Meeting - November 21, 1972

Attending

The name of Mr. G. Wyhowsky (OWRC-Toronto) should be added to the list of those attending.

PHENOLICS

(Method for sampling, preserving and analysing water samples for IJC Reference Studies)

SAMPLE COLLECTION

Two different methods are used to collect samples for the determination of phenol; the kind of launch, if one is used, and the location will determine which one. The first method is termed "indirect" and employs a deep water sampler such as a Knudson bottle; the other is a "direct" method using a sample bottle in a holder attached to the end of a pole or rod.

Vessels equipped for deep water sampling shall use the "indirect" method and sample the water at a minimum depth of 2 feet below its surface. The sample is transferred from the deep water sampler to a one liter glass or plastic (polyethylene) bottle, previously checked to determine that interfering phenolic compounds are not present.

On other moving launches or at fixed sampling sites, the "direct" bottle method shall be used. A one liter glass or plastic sample bottle previously checked to ensure the absence of interfering phenolic compounds is used to collect the sample at a minimum depth of 2 feet below the surface of the water (depth allowing, otherwise mid depth).

PRESERVATION

If the sample cannot be analysed within 4 hours then immediately upon collection it must be preserved. Add to it one gram (1.0) of copper sulphate ($CuSO_4 \cdot 5H_2O$) (in liquid or solid form) and phosphoric acid (H_3PO_4) to obtain pH 4.0.

When conditions permit, the sample shall then be kept in a dark place at a temperature of 5-10°C. The sample can be kept in this preserved state, that is from the time of collection to the time of analysis, up to a maximum of 24 hours. It must be analysed within this time period and it is preferable to carry out the analysis as soon as possible after the sample is collected.

ANALYSIS

Scope and Application

This method is applicable to the determination of phenolic compounds in Great Lakes waters. It is capable of measuring phenol and some ortho and meta substituted derivatives. It is not suitable for determining para substituted derivatives. The applicable range

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is 1.0 to 1000 ug/l phenol. By using an absorption cell providing a light path of 5 cm. the minimum detectable quantity is 1.0 ug/l phenol.*

Interferences

1) Oxidizing agents, such as chlorine and as detected by the liberation of iodine upon acidification in the presence of potassium iodide, are removed immediately after sampling by the addition of an excess of ferrous sulfate or sodium arsenite. If oxidizing agents are not removed, the phenolic compounds will be partially oxidized and the results will be low.

2) Sulfur compounds are removed by acidifying the sample to a pH less than 4.0 with H_3PO_4, using methyl orange or a pH meter, and aerating briefly by stirring prior to the addition of $CuSO_4$. This should eliminate the interferences of H_2S and SO_2.

3) Oils and tars contain phenols, so that alkaline extraction is required prior to the addition of $CuSO_4$. The pH of the sample is adjusted to 12-12.5 by the addition of NaOH pellets. The oil and tar are extracted from the aqueous solution by CCl_4. Discard the oil - or tar -containing layer. Any excess of CCl_4 in the aqueous layer is removed by warming on a water bath before proceeding with the distillation step.

A. Distillation Step:

1. Principle

The phenols are distilled at a more or less constant rate from the non-volatile impurities. The rate of volatilization of the phenols is gradual so that the volume of the distillate must equal that of the sample being distilled. The use of $CuSO_4$ during distillation of an acidic sample permits the formation of cupric sulfide without subsequent decomposition to H_2S. The acidic solution also prevents the precipitation of cupric hydroxide, which acts as an oxidizing agent toward phenols.

2. Apparatus

a) Distillation apparatus, all-glass, consisting of a 1-liter pyrex distilling apparatus with Graham condenser.**

b) pH meter.

* A lower level of detection was attained by using a 10 cm long micro-absorption cell.

** Corning No. 3360 or equivalent.

3. Reagents

All reagents must be prepared with distilled water free of phenols and chlorine.

a) Copper sulfate, $CuSO_4 \cdot 5H_2O$ solid, or a 10% solution.

b) Phosphoric acid solution, 1+9. Dilute 10 ml 85% H_3PO_4 to 100 ml with distilled water.

c) Methyl orange indicator: Dissolve 0.5 g methyl orange in 1 liter distilled water.

d) Special reagents for turbid distillates:
   1) Sulfuric acid, IN,
   2) Sodium chloride,
   3) Chloroform or ethyl ether,
   4) Sodium hydroxide, 2.5N: Dilute 41.7 ml 6N NaOH to 100 ml or dissolve 10 g NaOH in 100 ml distilled water.

4. Procedure

a) Measure 500 ml sample into a beaker, lower the pH to approximately 4.0 with the 1+9 H_3PO_4 solution using the methyl orange indicator or a pH meter, add 0.5 g copper sulfate, and transfer to the distillation apparatus. Use a 500-ml graduated cylinder as a receiver. The additions of H_3PO_4 and $CuSO_4$ must be omitted if the sample was preserved with these reagents.

b) Distill 450 ml of sample, stop the distillation and when boiling ceases, add 50 ml phenol-free distilled water to the distilling flask. Continue distillation until a total of 500 ml has been collected.

c) One distillation should prove sufficient for purification of the sample. Occasionally, however, the distillate is turbid. In this case, acidify the turbid distillate with 1+9 H_3PO_4, add 0.5 g copper sulfate, and distill as described in paragraph 4b above. If the second distillate is still turbid, an extraction process, described in paragraph 4d following, is required before distillation of the sample.

d) Treatment when second distillate is turbid: Extract a 500 ml aliquot of the original sample as follows: Add 4 drops methyl orange indicator and sufficient 1N H_2SO_4 to make the solution acidic. Transfer to a separatory funnel and add 150 g NaCl. Shake with five increments of chloroform, using 40 ml in the first increment and 25 ml in each of the increments following. Place the chloroform layer in a second separatory funnel and shake with three successive

increments of 2.5N NaOH solution, using 4.0 ml in the first increment and 3.0 ml in each of the next two increments. Combine the alkaline extracts, heat on a water bath until the chloroform has been removed, then cool and dilute to 500 ml with distilled water. Proceed with distillation as described in paragraphs 4a and 4b above

NOTE: Diethyl ether may be used instead of chloroform, especially if an emulsion forms when extracting the chloroform solution with NaOH. When ether is used, a better distribution coefficient is obtained for phenol between the ether and water phases and it is not necessary to use NaCl. Chloroform is preferred because of the hazards in handling ether.

B. Chloroform Extraction Step:

1. General Discussion

a) Principle: The steam-distillable phenols react with 4-aminoantipyrine at a pH of 10.0 ± 0.2 in the presence of potassium ferricyanide to form a colored antipyrine dye. This dye is extracted from aqueous solution with chloroform and the absorbance is measured at 460 mu. The concentration of phenolic compounds is expressed as ug/l of phenol (C_6H_5OH). This method covers the phenol concentration range of 1.0 to 1,000 ug/l with a sensitivity of 1 ug/l.

b) Interference: All interferences are eliminated or reduced to a minimum if the sample has been preserved and stored, and distilled in accordance with the foregoing instructions.

c) Minimum detectable concentration: The minimum detectable quantity is 1 ug/l phenol in a 500 ml distillate when a 25 ml $CHCl_3$ extraction with 5 cm cell is used in the photometric measurement.

2. Apparatus

a) Photometric equipment: One of the following, equipped with absorption cells providing light paths of 5 cm.
1) Spectrophotometer, for use at 460 mu.
2) Filter photometer, equipped with a filter exhibiting maximum light transmission near 460 mu.

b) Funnels: Buchner type with fritted disk (such as 15 ml Corning No. 36060 or equivalent.)

c) Filter paper: An appropriate 11 cm filter paper may be used for filtration of the chloroform extracts in place of the Buchner-type funnels and anhydrous sodium sulfate.

d) pH meter

e) Separatory funnel: 1,000 ml, Squibb form, with ground-glass stoppers and teflon stopcocks. At least eight are required.

f) Nessler tubes, matched, 50-ml, tall form.

3. Reagents

All reagents must be prepared with distilled water free of phenols and chlorine.

a) Stock phenol solution: Dissolve 1.00 g reagent-grade phenol in freshly boiled and cooled distilled water and dilute to 1,000 ml. Ordinarily this direct weighing of the phenol constitutes a standard solution. However, if extreme accuracy is required, standardize as directed in paragraph 4a below.

b) Intermediate phenol solution: Dilute 10.0 ml stock phenol solution to 1,000 ml in freshly distilled water; 1 ml=10.0 ug phenol. Prepare a fresh solution on each day of use.

c) Standard phenol solution: Dilute 50.0 ml intermediate phenol solution to 500 ml with freshly boiled and cooled distilled water; 1 ml=1.0 ug phenol. Prepare this solution within 2 hrs. of use.

d) Bromate-bromide solution, 0.10N: Dissolve 2.784 g anhydrous potassium bromate, $KBrO_3$, in distilled water, add 10 g potassium bromide (KBr crystals), dissolve, and dilute to 1,000 ml.

e) Hydrochloric acid, concentrated.

f) Standard sodium thiosulfate titrant, 0.025N: Prepare by dissolving 6.205 g $Na_2S_2O_3 \cdot 5H_2O$ in freshly boiled and cooled distilled water and diluting to 1,000 ml. Standard sodium thiosulfate solution may be preserved by adding 5 ml chloroform or 0.4 g NaOH per liter, or 4 g borax and 5-10 mg HgI_2 per liter.

Standardize with (1) biniodate or (2) dichromate:

1) Standard Potassium Biniodate Solution, 0.0250N: A stock solution equivalent in strength to 0.100N thiosulfate solution contains 3.249 g/l $KH(IO_3)_2$. The biniodate solution equivalent to the 0.0250N thiosulfate contains 812.4 mg/l $KH(IO_3)_2$ and may be prepared by diluting 250 ml stock solution to 1 liter.

Standardization: Dissolve approximately 2g KI, free from iodate, in an Erlenmeyer flask with 100 to 150 ml distilled water; add

10 ml 1+9 H_2SO_4, followed by exactly 20.00 ml standard biniodate solution. Dilute 200 ml and titrate the liberated iodine with the thiosulfate titrant, adding starch toward the end of the titration, when a pale straw color is reached. Exactly 20.00 ml 0.0250N thiosulfate should be required when the solutions under comparison are of equal strength. It is convenient to adjust the thiosulfate solution to exactly 0.0250N.

2) Standard Potassium Dichromate Solution, 0.0250N: Potassium dichromate may be substituted for biniodate. A solution equivalent to 0.0250N sodium thiosulfate contains 1.226 g/l $K_2Cr_2O_7$. The $K_2Cr_2O_7$ should be previously dried at 103°C for 2 hr. The solution should be prepared in a volumetric flask.

Standardization: Same as with biniodate, except that 20.00 ml standard dichromate solution are used. Place in the dark for 5 min., dilute to approximately 400 ml, and titrate with 0.0250N thiosulfate solution.

g) Starch solution: Prepare the aqueous solution by adding a cold water suspension of 5 g arrowroot or soluble starch to approximately 800 ml of boiling water, with stirring. Dilute to 1 liter, allow to boil a few minutes, and let settle overnight. Use the clear supernate. This solution may be preserved with 1.25 g salicylic acid per liter or by the addition of a few drops of toluene.

h) Ammonium chloride solution: Dissolve 50 g NH_4Cl in distilled water and dilute to 1,000 ml.

i) Ammonium hydroxide, concentrated.

j) Aminoantipyrine solution: Dissolve 2.0 g 4-aminoantipyrine in distilled water and dilute to 100 ml. This solution should be prepared each day of use.

k) Potassium ferricyanide solution: Dissolve 8.0 g $K_3Fe(CN)_6$ in distilled water and dilute to 100 ml. Filter if necessary. Prepare fresh each week of use.

l) Chloroform.

m) Sodium sulfate, anhydrous, granular.

n) Potassium iodide, crystals.

4a <u>Standardization of Phenol Solution</u>

1) To 100 ml distilled water in a 500 ml glass-stoppered conical flask, add 50.0 ml stock phenol solution and 10.0 ml 0.1N bromate-

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bromide solution. Immediately add 5 ml conc HCl and swirl the stoppered flask gently. If the brown color of free bromine does not persist add 10.0 ml portions of bromate-bromide solution until the color does persist. Keep the flask stoppered and allow to stand for 10 min; then add approximately 1 g KI. Usually four 10 ml portions of bromate-bromide solution are required if the stock phenol solution contains 1,000 mg/l phenol.

2) Prepare a blank in exactly the same manner, using distilled water and 10.0 ml 0.1N bromate-bromide solution. Titrate the blank and sample with the 0.025N sodium thiosulfate titrant, using starch solution as the indicator.

3) Calculate the concentration of the phenol solution as follows:

$$\text{mg/l phenol} = 7.842\ (AB-C)$$

where A=ml thiosulfate for blank; b=ml bromate-bromide solution used for sample divided by 10; and c=ml thiosulfate used for sample.

4b <u>Procedure</u>

1) Place 500 ml of the distillate, or a suitable aliquot diluted to 500 ml, in a 1-liter beaker. If all 500 ml of distillate is used, it may not contain more than 50 ug (0.1 mg/l) phenol. If the sample is known to contain more than 50 ug phenol, a smaller aliquot must be used. Practically, the smallest aliquot would be 50 ml that contains not more than 50 ug (1 mg/l) phenol.

2) If the approximate phenol concentration of the original sample is not known, determine by a preliminary check the proper aliquot of the distillate and of the $CHCl_3$ to use for the final determination. This may be done without $CHCl_3$ extraction by carrying out the reaction in 50 ml nessler tubes and comparing against suitable phenol standards.

3) Prepare a 1000 ml distilled water blank and a series of 500 ml phenol standards containing 1,2,4,6,8, and 10 ug/l phenol.

4) Treat sample and standards as follows: Add 10 ml ammonium chloride solution and adjust with conc NH_4OH to pH 10.0 ± 0.2. Transfer to the 1-liter separatory funnels, add 3.0 ml aminoantipyrine solution, mix well, add 3.0 ml potassium ferricyanide solution, again mix well, and allow the color to develop for 3 min. The solution should be clear and light yellow. For the blank, use double portions of reagents.

5) Extract immediately with $CHCl_3$, using 25 ml. Use 50 ml for the blank. Shake the separatory funnel at least 10 times, allow the $CHCl_3$ to settle, shake again 10 times, and allow the $CHCl_3$ to settle again.

6) Filter each of the chloroform extracts through the filter paper or through the fritted-glass funnels containing a 5-g layer of the anhydrous sodium sulfate. Collect the dried extracts in clean cells for the absorbance measurements; do not add more $CHCl_3$.

7) Read the absorbance of the sample and standards against the blank at a wavelength of 460 mu. Plot absorbance against ug/l of standard phenol solutions for the calibration curve. Estimate the phenol concentration of the sample from the calibration curve. A separate calibration curve must be constructed for each photometer and each curve must be checked periodically to ensure reproducibility.

5. Precision and Accuracy

In one laboratory (WQB), 1.0 $\pm$ 0.2 ug/l phenol was measured at a 95% level of confidence. 10.0 $\pm$ 0.5 ug/l phenol was measured at 95% level of confidence. Over the range 1.0 to 10.0 ppb, relative errors of 8% to 3% were found.

6. Reference

Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971, APHA. AWWA. WPCF.

APPENDIX 7

Reprinted from ANALYTICAL CHEMISTRY, Vol 37, Page 1709, December 1965
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Determination of Carboxylic Acids Present as Esters in Plasticizers and Polymers by Transesterification and Gas Chromatography

STANLEY J. JANKOWSKI and PATRICIA GARNER

Celanese Corp. of America, Central Research Laboratories, Summit, N. J.

▶ A gas chromatographic procedure is proposed for the determination of dicarboxylic and monocarboxylic acids present as ester functionalities in plasticizers and polymers. These carboxylic acids are converted to their methyl esters by transesterification using a sodium methoxide–methanol–methyl acetate reagent, extracted with benzene containing diphenyl ether, as an internal standard, and separated and determined by gas chromatographic techniques. Conversion to the methyl esters has been quantitative for a variety of aliphatic and aromatic carboxylic acid esters of aliphatic and aromatic mono- and polyhydroxy compounds. Acid contents in the range 3 to 81% have been studied. Free carboxylic acids are not converted to their methyl esters by this technique.

Carboxylic acids are present as ester functionalities in an extensive variety of materials which are of importance in the chemical industry. Coatings, fats and oils, fibers, films, and plasticizers are areas where ester functionalities are frequently encountered. The complexity of the material varies from simple esters, such as dioctyl phthalate or polyethylene terephthalate, to highly complex mixtures such as alkyd resins.

Wet chemical analysis (*6*) of ester functionalities has consisted of saponification of the material with aqueous or alcoholic caustic followed by recovery and separation of the liberated carboxylic acids or their salts. The procedures are laborious and time consuming, and quantitative separation of the individual acids present is seldom achieved.

Infrared absorption spectrophotometry has been used to determine ester functionalities. However, its application is limited to very simple mixtures. Because of similarity of the infrared spectra of aliphatic carboxylic acid esters, the infrared approach also lacks sensitivity for the analysis of small amounts of one ester in the presence of large amounts of another ester. Thus, as much as 10% of an unknown ester present in a polyester polymer or resin will not be detected unless further wet chemical operations are undertaken.

Ultraviolet absorption spectrophotometry has been applied in the analysis of esters containing aromatic or unsaturated acids. This method is very sensitive but its application is limited to the most simple mixtures. The presence of several aromatic and/or unsaturated functionalities requires separation of the components, prior to measurement of the specific components by ultraviolet absorption techniques.

Gas chromatography has increased the possibilities of analyzing esters rapidly with excellent precision. Currently, direct determination of esters by gas chromatographic techniques is limited to those compounds having sufficient vapor pressure at the operating temperature of the analytical column to permit elution of the ester in a reasonable period of time. The esters must be stable at the temperatures required for introduction of the sample onto the chromatographic columns. Esters with boiling points as high as 400°C. have been analyzed in this laboratory by gas chromatographic techniques.

Esposito and Swann (*2*) have reported the use of a transesterification technique for identification of some 19 carboxylic acids used in the production of synthetic resin. No quantitative results were presented by these workers, and the work was limited to alkyd and polyester coating resins. Percival (*7*) has extended this work to include semiquantitative results. The work was limited to polyester resins, and reaction times of 18 to 42 hours are required for transesterification.

Work in this laboratory has shown these techniques are not applicable to the analysis of high molecular weight polyester polymers such as polyethylene terephthalate fiber and film or spandex fibers.

Reflux of these materials with up to a 100-fold excess of 0.5*N* lithium or sodium methoxide in methanol or 10% boron trifluoride in methanol for periods of up to 8 hours gave no significant amounts of the corresponding dimethyl esters. Conversion was less than 1%.

Use of pressure equipment to increase the reaction temperature to 100°C. did not significantly improve the results.

EXPERIMENTAL

Apparatus and Materials. Chromatographic Unit. The instrument used to obtain the chromatograms was a Model A-700 Aerograph Autoprep (Wilkens Instrument and Research, Inc.) equipped with a Brown Electronik Recorder (Minneapolis-Honeywell Regulator Co.).

Operating conditions were detector cell temperature, 250° C.; detector cell current, 175 ma.; injection port temperature, 250° C.; helium flow at exit, 70 cc. per minute; column temperature, Ucon-50HB280X, 170° C., and Bentone 34–Carbowax 20M, 195° C.

Column Preparation. The Ucon column packing was made with 15% by weight of liquid phase on 60- to 80-mesh Chromosorb W. The Bentone-

Carbowax column was prepared with 5% by weight Bentone 34 and 15% by weight of Carbowax 20M on 60- to 80-mesh Chromosorb W. An 8-foot length of 1/4-inch copper tubing was used for each column. The Bentone-Carbowax column was conditioned for 24 hours at 200° C. prior to use.

REAGENTS. Sodium methoxide in methanol (1 molal) was prepared by slowly adding 54 grams of sodium methoxide (Matheson, Coleman & Bell) to 1000 ml of methanol.

A standard diphenyl ether solution was made by adding 2.5 grams of diphenyl ether (Eastman Organic Chemicals) to a 100-ml volumetric flask and diluting with benzene.

Procedure. An air dried carboxylic acid ester-containing sample, weighing 0.2 to 0.5 gram was placed in a 250-ml. iodine flask to which had been added 25 ml of sodium methoxide in methanol solution and 25 ml of methyl acetate. A short West reflux condenser was attached to the flask which was then placed on a hot plate and allowed to reflux for 1 hour if the sample was a polyester or 2 hours if the sample was a Spandex polymer. After refluxing, the flask was allowed to cool and 25 ml of 1N acetic acid, 25 ml of saturated aqueous sodium chloride solution and 10 ml. of standard diphenyl ether solution were added. The flask was then shaken well and the contents were transferred to a separatory funnel. The solution was allowed to settle and the aqueous phase was drawn off and discarded. The benzene layer was placed in a serum bottle or small Erlenmeyer flask that could be stoppered with a rubber septum. A boiling stone was added to the benzene phase to avoid losses due to bumping. The benzene phase was evaporated to about 10 ml. on a steam bath or low temperature hot plate. After cooling, the container was stoppered and was then ready for chromatographic analysis.

The 8-foot Bentone-Carbowax column was mounted in position after being initially conditioned for 24 hours at 200° C., and heated to operating temperature. About 5 μl. of sample were introduced onto the column and all emerging volatile components were recorded. If dimethyl suberate was formed, the 8-foot Ucon column was used. The resulting recorded areas were measured with a planimeter. From the data of the relative areas of the internal standard and the dimethyl ester, the amount of carboxylic acid, present as an ester functionality in the original sample, was calculated using the appropriate response factor found in Table I.

Table I. Relative Detector Response Factors and Retention Times for Various Dimethyl Esters

Compound	Relative detector response	Relative retention time
Diphenyl ether	1.00	1.00 (1.00)[a]
Dimethyl succinate	1.00	0.18
Dimethyl glutarate	1.00	0.31
Dimethyl adipate	0.99	0.45
Dimethyl pimelate	0.99	0.68
Dimethyl suberate	0.93	1.00 (1.10)[a]
Dimethyl azelate	0.94	1.31
Dimethyl sebacate	0.93	1.83
Dimethyl terephthalate	0.89	2.02
Dimethyl isophthalate	0.88	2.26
Dimethyl phthalate	0.83	2.52

[a] When Ucon-50HB280X column is used.

RESULTS AND DISCUSSION

The response factors and retention times, relative to diphenyl ether, for a number of the methyl esters of carboxylic acids commonly found in plasticizers and polymers have been determined and are shown in Table I. All are readily separated under the simple isothermal conditions used except dimethyl suberate which is infrequently encountered but can be readily separated on a Ucon-50HB280X column.

The gas chromatographic separation of the three isomeric dimethyl phthalate esters has not been reported previously. The gas chromatographic separation of the methyl esters of fatty acids has been intensively investigated (*1, 4, 5*) and only the conversion of the fatty acid esters to their methyl esters was of interest in this investigation. Ucon or silicone grease columns are used in this laboratory for separation and analysis of the methyl esters of fatty acids.

A comparison of results for a variety of materials obtained by the transesterification technique proposed here and the older techniques of saponification, isolation, and determination is shown in Table II. There is good agreement in the results of the two techniques and the relative simplicity, specificity and speed of the transesterification procedure indicate studies of its application to related materials would be fruitful.

Free carboxylic acids, such as adipic, palmitic, and terephthalic, are not converted to their methyl esters by this transesterification technique making this method specific for ester functionalities.

The work carried out on the attempted transesterification of polyester polymers with methoxide-methanol reagents suggested traces of water and the relative insolubility of starting polymers, and resulting dimethyl ester in methanol were responsible for the low levels of conversion to the dimethyl esters. Presence of water results in the formation of the metal hydroxide, which leads to the formation of the metal salts of the acid. The metal salts of the acids are not readily converted to the corresponding methyl esters. Methyl acetate is believed to convert the sodium hydroxide, when formed because of presence of water, to methanol and sodium acetate which is innocuous. Solubility of various dimethyl esters in the reagent system reported here is excellent.

Sodium methoxide in methyl acetate alone could not be used because of undesirable side reactions. High yields of methyl acetoacetate have been reported for this mixture (*3*). Substitution of ethyl acetate for methyl acetate decreases the time required for digestion of the polymer samples, but the resulting reaction products are mixed methyl-ethyl esters which are unsatisfactory for analytical purposes. Use of a ethanol-ethyl acetate-sodium ethoxide system would eliminate this difficulty but did not offer sufficient advantage to justify additional investigations required.

Table II. Analysis of Ester Containing Materials

Material	Acid present	Transesterification	Saponification
Polyethylene terephthalate (commercial fiber)	Terephthalic	81.0 (σ = 1.9)	82
Polyester fiber	Isophthalic	10.0	10
	Terephthalic	59.7	60
Spandex fiber	Adipic	40.5 (σ = 1.0)	41
Diethylene glycol adipate	Adipic	66.6	67.6
Diphenyl phthalate	Phthalic	52.2	52.2
Dibutyl terephthalate	Terephthalic	58.0	58.4
Dibutyl sebacate	Sebacic	60.6	62.9
Dibenzyl succinate	Succinic	35.5	38.2
Dibenzyl phthalate	Phthalic	48.0	47.8
Sorbitan monolaurate	Myristic	11.7	11.5
	Lauric	30.1	31.9
	Capric	3.4	3.3
	Caprylic	3.0	2.8

Recovery of the hydroxyl compounds resulting from transesterification of the samples is not quantitative. This suggests the hydroxy compound may be undergoing dehydration in this media although in those polymers containing ethylene glycol none of the expected products such as acetaldehyde, ethylene oxide, methyl cellosolve, or polyethylene glycol have been recovered.

ACKNOWLEDGMENT

The authors are grateful to C. L. Kolb for his interest and advisory assistance during the course of these investigations and to R. A. Janiak who carried out some of the analysis.

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Received for review August 30, 1965. Accepted October 4, 1965.

APPENDIX-LL

PRELIMINARY
SUBJECT TO CHANGE

ADDENDUM TO
METHODS FOR ORGANIC PESTICIDES
IN WATER AND WASTEWATER
B. METHOD FOR POLYCHLORINATED
BIPHENYLS IN WATER

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MAY 1972

ENVIRONMENTAL PROTECTION AGENCY

NATIONAL ENVIRONMENTAL RESEARCH CENTER

CINCINNATI, OHIO

45268

B. METHOD FOR POLYCHLORINATED BIPHENYLS IN WATER

1. Scope and Application

1.1 This method covers the determination of certain polychlorinated biphenyls PCB's Aroclors[1], including: 1016, 1221, 1232, 1242, 1248, 1254 and 1260.

1.2 The method is an extension of the Environmental Protection Agency's "Method for Organochlorine Pesticides" (1). It is designed so that determination of both the PCB's and the organochlorine pesticides may be made on the same sample.

2. Summary

2.1 The PCB's and the organochlorine pesticides are co-extracted by liquid-liquid extraction and, insofar as possible, the two classes of compounds separated from one another prior to gas chromatographic determination. A combination of the standard Florisil column/clean-up procedure and the silica gel microcolumn/separation procedure of Leoni (2) are employed. Identification is made from gas chromatographic patterns obtained through the use of two or more unlike columns. Detection and measurement is accomplished using an electron capture, microcoulometric, or electrolytic conductivity detector. Techniques for confirming qualitative identification are suggested.

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[1]Trade name of the Monsanto Co., St. Louis, Missouri

3. Significance

3.1 The extensive and widespread use of PCB's has resulted in their presence in all parts of the environment. Like the organochlorine pesticides the PCB's are very persistent. While they are generally less toxic than the organochlorine pesticides they do have lethal effects on fish and other aquatic animals. Thus, it is imperative that we identify and quantitate the PCB's present in the environment.

3.2 Because of their cumulative nature, we need to detect small quantitaties (μg/l and less) of the PCB's in water.

4. Interferences

4.1 Refer to EPA Method for Organochlorine Pesticides. Phthalate esters, certain organophosphorus pesticides, and elemental sulfur will interfere when using electron capture for detection.

4.2 Organochlorine pesticides and other halogenated compounds constitute interferences in the determination of PCB's. Most of these are separated by the method described below. However, certain compounds, if present in the sample, will occur with the PCB's. Included are: Sulfur, Heptachlor, aldrin, chlordane, mirex, and to some extent o, p'-DDT and p,p'-DDT.

5. Method of Analysis

5.1 Extraction of Sample

5.1.1 Transfer a measured volume of sample (1-liter) to a 2-liter separatory funnel equipped with a Teflon stopcock. Extract the sample twice with 60 ml of 15% ethyl ether in hexane and once with 60 ml of hexane only according to

Part II, A, 5.1.

5.1.2 Dry the combined extracts by pouring over a column of anhydrous sodium sulfate and concentrate to 10 ml in a Kuderna-Danish evaporator. Qualitatively analyze the sample by gas chromatography using the non-polar column described in Table 2, with an electron capture detector. From the response obtained determine:

a. If there are any organochlorine pesticides present,

b. If there are any PCB's present.

c. If there is a combination of a and b,

d. If the response is too complex to determine a, b, or c.

If no response, concentrate to 1.0 ml or less, as required, according to Part II, A, 5.1.4 and repeat the analysis looking for a, b, c, and d.

5.1.3 If condition a exists, quantitatively determine the organochlorines pesticides according to Part II, A, 5.2 and 5.3.

5.1.4 If condition b exists, PCB's only are present, no further separation or clean-up is necessary. Quantitatively determine the PCB's according to 5.6.1.

5.1.5 If condition c exists, compare peaks obtained from sample to those of standard Aroclors and make a judgment as to which Aroclors may be present. To separate the PCB's from the organochlorine pesticides, continue as outlined below.

5.1.6 If condition d exists, apply standard Florisil column procedure, Part II, A, 5.2.2. The first eluate from the Florisil column will contain certain of the organochlorine

pesticides and all of Aroclors 1221, 1232, 1242, 1248, 1254, and 1260, if they are present in the sample. Analyze the first eluate as indicated in 5.1.2 above. Analyze the second eluate according to Part II, A, 5.3.

5.2 Silica Gel Micro Column Separation Procedure

5.2.1 Apparatus

5.2.1.1 Micro Column - Constructed of borosilicate glass tubing, according to Figure 1.

5.2.1.2 Erlenmeyer Flask - 250 ml, glass stoppered (24/40)

5.2.1.3 Desiccator - Vacuum, bobosilicate glass, 160 mm diameter x 255 mm high.

5.2.2 Standards, Reagent and Solvents

5.2.2.1 Standards - Aroclors 1221, 1232, 1242, 1248, 1254 and 1260, Monsanto Co., St. Louis, MO and polychlorinated biphenyl isomers (99% pure), Analabs, 80 Republic Drive, North Haven, CT 06473.

5.2.2.2 n-Hexane - Pesticide quality (not mixed hexanes).

5.2.2.3 Benzene - Pesticide quality

5.2.2.4 Silica Gel - Davison Code 950-08-08-226 (60-200 mesh).

5.2.2.5 Glass Wool - Pre-extracted with Hexane.

5.2.2.6 Sodium Sulfate - Anhydrous, granular, conditioned for 2 hours @ 400°C.

5.2.2.7 Gas Chromatographic Column - liquid phase OV-1

5.3 Activation for Silica Gel

5.3.1 Place about 20 g of silica gel in an open, tared, glass stoppered, 250 ml Erlenmeyer flask and heat at 130°C for

8 hours. Remove from the oven and weigh, while still hot, on a triple beam balance. Then seal with ground glass stopper and store in vented desiccator, containing no desiccant, until cool. Then deactivate with 5% distilled water. Add the water dropwise down the side of the flask and shake until all lumps are broken and the silica gel is free flowing. Store for about 8 hours in a sealed desiccator, containing no desiccant, prior to use to insure equal distribution of the water. The proper activation state will be maintained for about 10 days, if stored in a well sealed flask in the desiccator.

5.4 Preparation of the Chromatographic Column

5.4.1 Pack the lower, 2mm I.D. section of the micro column with glass wool and add 1 g ± 20 mg of activated silica gel to the column. Tap the column to pack the silica gel. This should result in a column of adsorbent ~10 cm high. Mark this level, and for future work fill to the mark. Add 1 cm of sodium sulfate to the top of the column and tap to settle.

5.4.2 Pipet a 1.0 ml aliquot of the concentrated sample extract (previously reduced to a total volume of 2.0 ml) on to the column (do not prewash the column). As the last of the sample passes into the sodium sulfate layer, rinse down the internal wall of the column twice with a minimum of n-hexane. Then assemble the upper section of the column. As the last of the n-hexane rinse reaches the surface of the sodium sulfate, add enough n-hexane (volume predetermined, see 5.5

below) to just elute all of the PCB's present in the sample. Apply air pressure until the effluent flow is 1 ml/min. Collect the desired volume of eluate (predetermined, see 5.5 below) in an accurately calibrated ampul. As the last of the n-hexane reaches the surface of the sodium sulfate, release the air pressure and change the collection ampul

5.4.3 Fill the column with benzene, again apply air pressure and adjust flow to 1 ml/min. Collect the eluate until all of the organochlorine pesticides of interest have been eluted (volume predetermined, see 5.5 below).

5.5 Determination of Elution Volumes

5.5.1 The elution volumes for the PCB's and the pesticides depend upon a number of parameters which are difficult to control. These include variation in:

a. Mesh size of the silica gel

b. Adsorption properties of the silica gel.

c. Polar contaminants present in the eluting solvent.

d. Polar materials present in the sample and sample solvent.

e. The dimensions of the microcolumns.

Therefore, the optimum elution volume must be experimentally determined each time a parameter is changed. To determine the elution volumes, add standard mixtures of Aroclors and pesticides to the column and collect 1 ml elution volumes.

Analyze the individual eluates by gas chromatography and determine the cut-off volume for n-hexane and for benzene. Table 1 lists the retention order of the various Aroclor components and of the pesticides. Using the data in this table, prepare the proper standard mixtures required for analysis of the n-hexane and benzene eluates.

5.5.2 In determining the volume of hexane required to elute the PCB's, the sample volume (1 ml), the volume of hexane retained by the silica gel (~0.5 ml), and the volume of n-hexane used to rinse the column wall must be considered. Thus, if it is determined that a 10.0 ml elution volume is required to elute the PCB's, the volume of hexane to be added in addition to the sample volume but including the rinse volume should be 9.5 ml.

5.5.3 Figure 2 shows that as the average chlorine content of a PCB mixture decreases the solvent volume for complete elution increases. Qualitative determination (5.1.2) indicates which Aroclors are present and provides the basis for selection of the ideal elution volume. This helps to minimize the quantity of organochlorine pesticides which will elute along with the low percent chlorine PCB's and insures the most efficient separations possible for accurate analysis.

5.6 Quantitative Determination

5.6.1 Measure the volume of the n-hexane eluate, containing the PCB's, and inject 1 to 5 µl into the gas chromatograph.

(Conditions are listed in Table 2). If necessary, adjust the volume of the eluate to give linear response to the electron capture detector (Detection limit approximately 0.01 ng/µl). The microcoulometric or the electrolytic detector may be employed to improve specificity for samples having higher concentrations of PCB's (Detection limit approximately 10 ng/µl).

5.6.2 Calculations

5.6.2.1 Since polychlorinated biphenyls occur in the environment in varying degrees of complexity:

a. As the original mixture, unchanged, eg., Aroclor 1242.

b. As a combination of Aroclors, eg., 1242 + 1260.

c. As metabolized or biodegraded products of the original Aroclor or combination of Aroclors.

d. As a combination of a, b, and c, it is impossible to prescribe a simple method for quantitative determination.

5.6.2.2 For the least complicated situation, a , compare quantitative Aroclor reference standards (eg. 1242, 1248) to the unknown. Measure and sum the areas of the unknown and the reference Aroclor and calculate the result as follows:

$$\text{Micrograms/liter} = \frac{[A]\ [B]\ [Vt]}{[\ Vi]\ [Vs]} \times 2$$

$$A = \frac{\text{ng of Standard Injected}}{\Sigma \text{ of Peak Areas}} = \frac{ng}{mm^2}$$

$$B = \Sigma \text{ of Sample Peak Areas} = mm^2$$

Vi = Volume of sample injected (µl)

Vt = Volume of total extract (µl)

Vs = Volume of water sample extracted (ml).

5.6.2.3 For situation b, combination of intact Aroclors, prepare mixtures of Aroclor reference standards and compare them to the unknown until similar chromatograms are obtained. Calculate the result as in 5.6.2. At best, this is a time consuming procedure and the analyst may choose to use the approach described below

5.6.2.4 The most practical calibration procedure for complex mixtures of PCB's involves:

a. Identification of the individual isomers,

b. Grouping them according to the number of chlorine atoms present in the molecule,

c. Reporting the amount of the various isomeric groups present based on the average response factor obtained for each group.

Since the response factors for PCB isomers, containing the same number of chlorine atoms, may vary, the average response factor for the isomers in the group should be used for calculation. To obtain the average response factor for each isomeric group to the electron capture detector, prepare standard mixtures of the individual pure isomers and determine gas chromatographic response. This operation is not necessary when using the microcoulometric detector, since its response is directly proportional to the amount of chlorine entering the cell per unit time, ie, the number of chlorine atoms in the molecule.

The various isomeric groups are located by experimentally duplicating the chromatogram shown in Figure 3. Obtain the chromatogram on the OV-1 column by injecting a mixture of Aroclors 1221, 1242, 1248, 1254 and 1260 (1232 is not included because it is a mixture of 1221 and 1242), 10 ng each in a total of 100 ml of hexane. There are 209 possible isomers of PCB's (5). Many of them overlap and it is impossible to resolve them by common gas chromatographic techniques. In the case of the above mixtures, the isomers have been identified as accurately as possible using GC-MS. Minor amounts of various isomers in the mixture do overlap and are unavoidably included in certain isomeric groups.

Calculate the results by summing the areas of the peaks in each isomeric group and applying the appropriate response factor as indicated below:

$$\text{microgram/liter } Cl_x = \frac{[A]\ [B]\ [Vt]}{[Vi]\ [Vs]}$$

$$A = \frac{\Sigma \text{ ng } Cl_x \text{ Standard}}{\Sigma \text{ Areas } Cl_x \text{ Standard}}$$

B = Σ Sample Areas of Cl_x

Vt = Volume of total extract (µl)

Vi = Volume of extract injected (µl)

Vs = Volume of water sample extracted (ml)

Cl_x = Isomeric group, where x = 1 thru 8.

5.6.3 Confirmatory Techniques

5.6.3.1 Unequivocal identification of PCB's can be made by GC-MS when present in sufficient concentration (approximately 20 ng/µl in the final extract). The methods described by Bonelli (6) and Budde (7) are useful for this purpose. When GC-MS is not available, separate GC analysis using both non-polar and polar columns will give added confidence in the qualitative determination. The use of specific halogen detectors, such as the microcoulometric and electrolytic conductivity, will eliminate non-halogen interferences and further support the identification. The concentration of PCB's required is about 10 ng/µl in the final extract.

5.6.3.2 The Monsanto method (8) for PCB's which incorporates a two-step chemical treatment - saponification with alcoholic potassium hydroxide followed by sulfuric acid effectively eliminates many interferences while the PCB's are retained intact.

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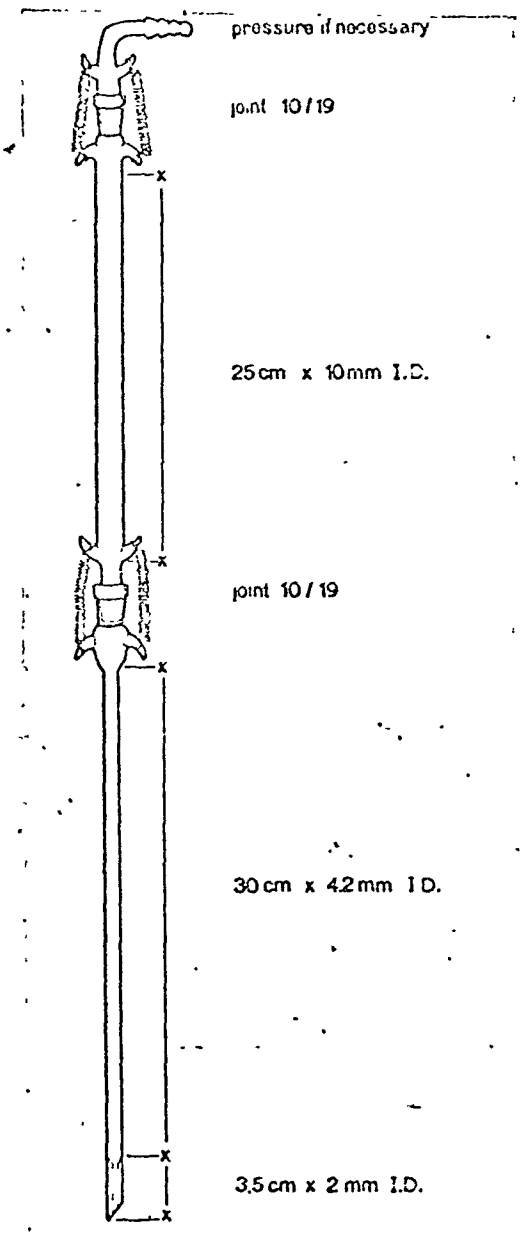


Fig. 1. The microcolumn.

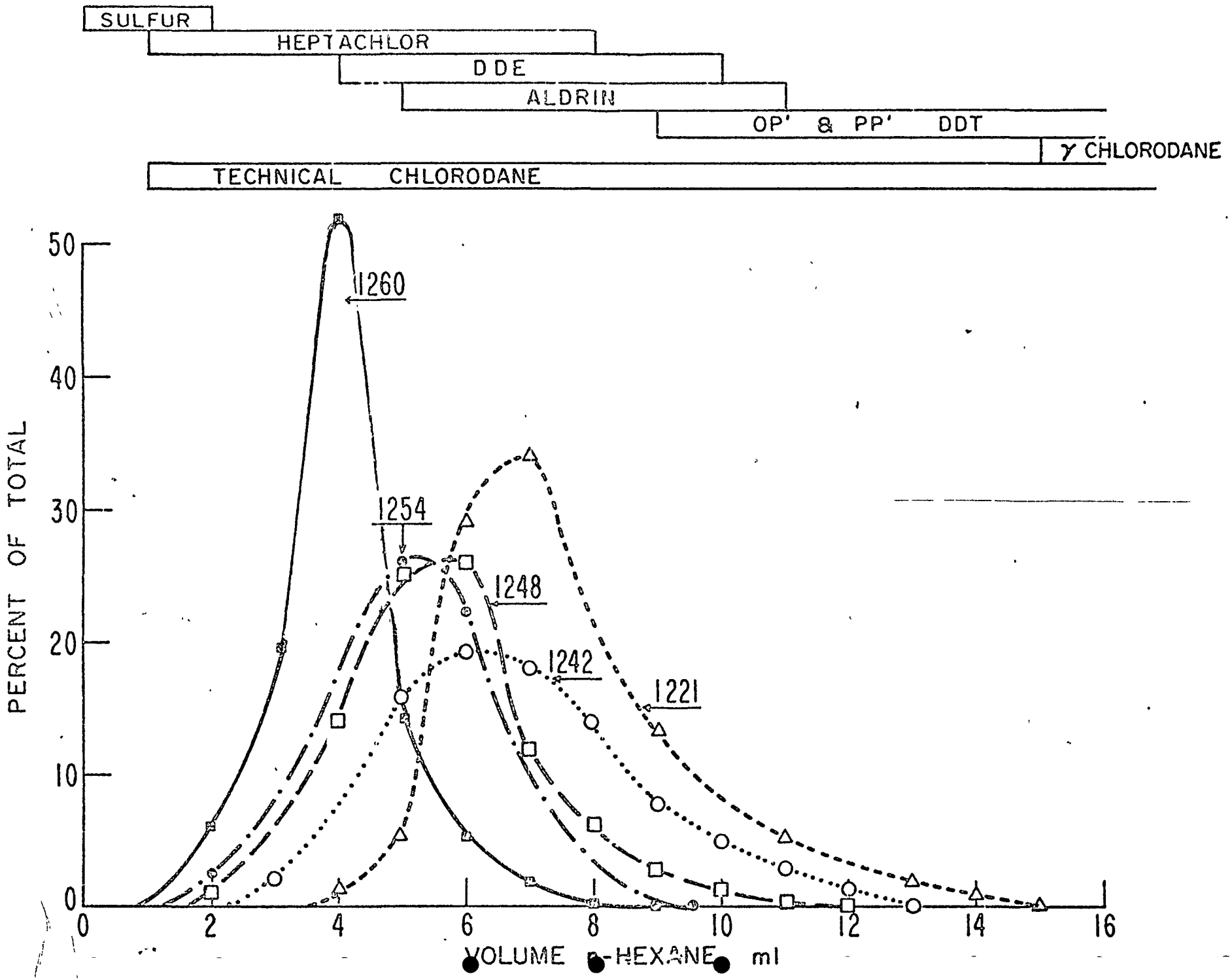
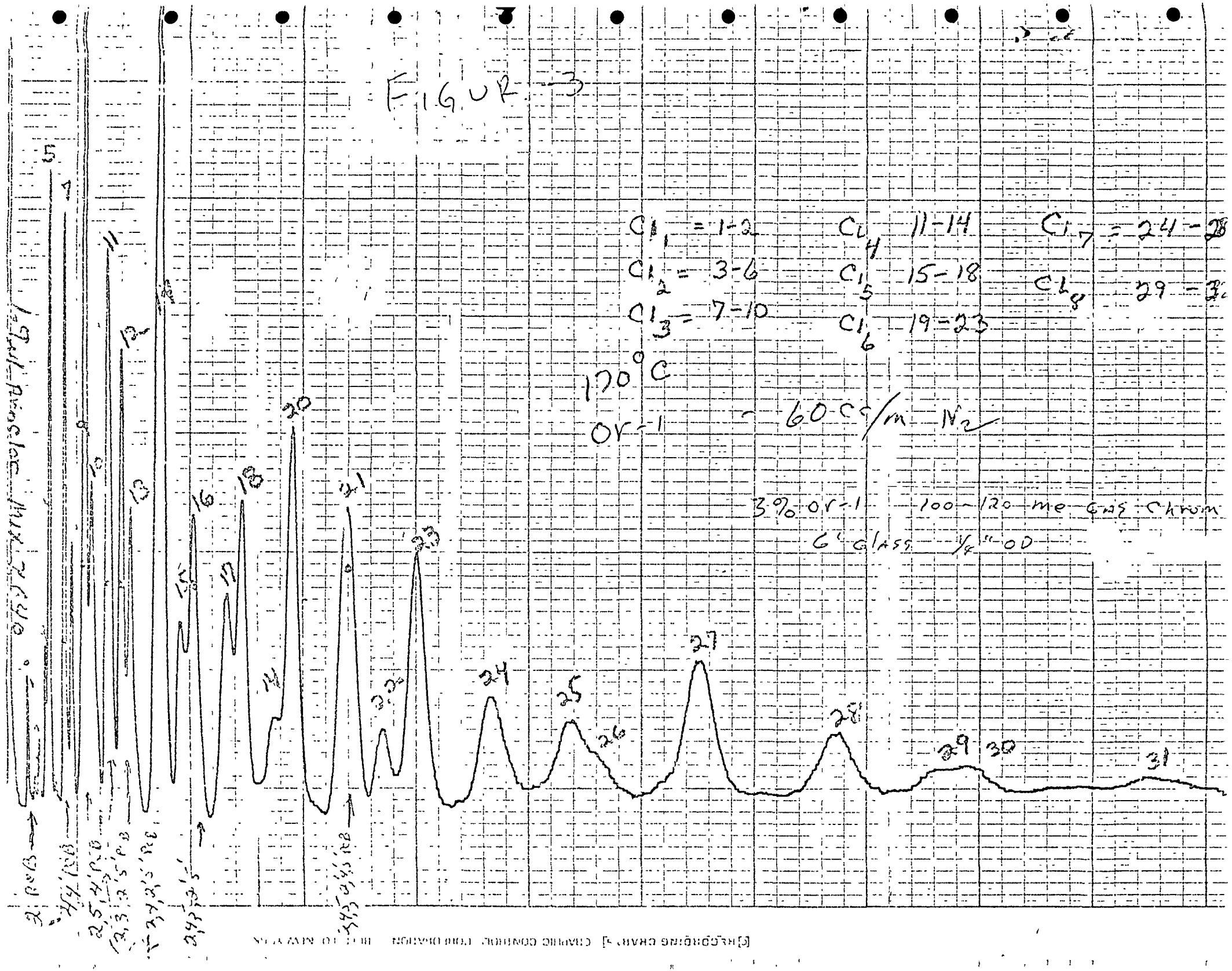

SULFUR
HEPTACHLOR
DDE
ALDRIN
OP' & PP' DDT
γ CHLORODANE
TECHNICAL CHLORODANE
1260
1254
1248
1242
1221
PERCENT OF TOTAL
0
10
20
30
40
50
0
2
4
6
8
10
12
14
16
VOLUME n-HEXANE ml

FIGURE 3


Cl1 = 1-2
Cl2 = 3-6
Cl3 = 7-10
Cl4 11-14
Cl5 15-18
Cl6 19-23
Cl7 = 24-28
Cl8 29 = 3
170°C
OV-1 ~ 60 cc/m N2
3% OV-1 100-120 me GAS Chrom
6' GLASS 1/4" OD
Log Peak Area/Max. Area %
Time (min)

APPENDIX V

3

STATE OF INDIANA

INDIANAPOLIS 46206

STREAM POLLUTION CONTROL BOARD

1330 West Michigan Street
633-4420

January 11, 1973

Mr. Valdas V. Adamkus
Acting Regional Administrator
U.S. Environmental Protection Agency
Region V
1 North Wacker Drive
Chicago, Illinois 60606

Dear Mr. Adamkus:

Re: Non-Thermal Recommendations of the Public Session of Lake Michigan States and the U.S. Environmental Protection Agency - November 9, 1972

This will acknowledge your letter of December 26, 1972, regarding the above subject.

Pursuant to the recommendations of the participants of the above session, the State of Indiana has initiated a PCB and phthalates monitoring program in the Lake Michigan Basin. In addition, we have expanded our existing metals monitoring program in the Basin.

The first set of samples for PCB and phthalate analysis was collected on November 27 and 28, 1972. This set included 24-hour composite samples from a few municipal sewage treatment plants and grab samples from receiving waters. A second, similar, set of samples was collected on December 20 and 21, 1972.

Starting this month, samples will be collected from permanent stream and Lake Michigan sampling stations on a regular basis. Municipal sewage treatment plants in the Basin will be sampled at intervals determined on the basis of the results of two sets of grab samples. Various industries in the basin will be required to do their own monitoring.

We will be pleased to meet with Dr. Zeller to discuss our monitoring programs in more detail.

Very truly yours,

Oral H. Hert

Oral H. Hert
Technical Secretary

JLWinters/dsc
cc: Dr. Robert W. Zeller
Steve Kin